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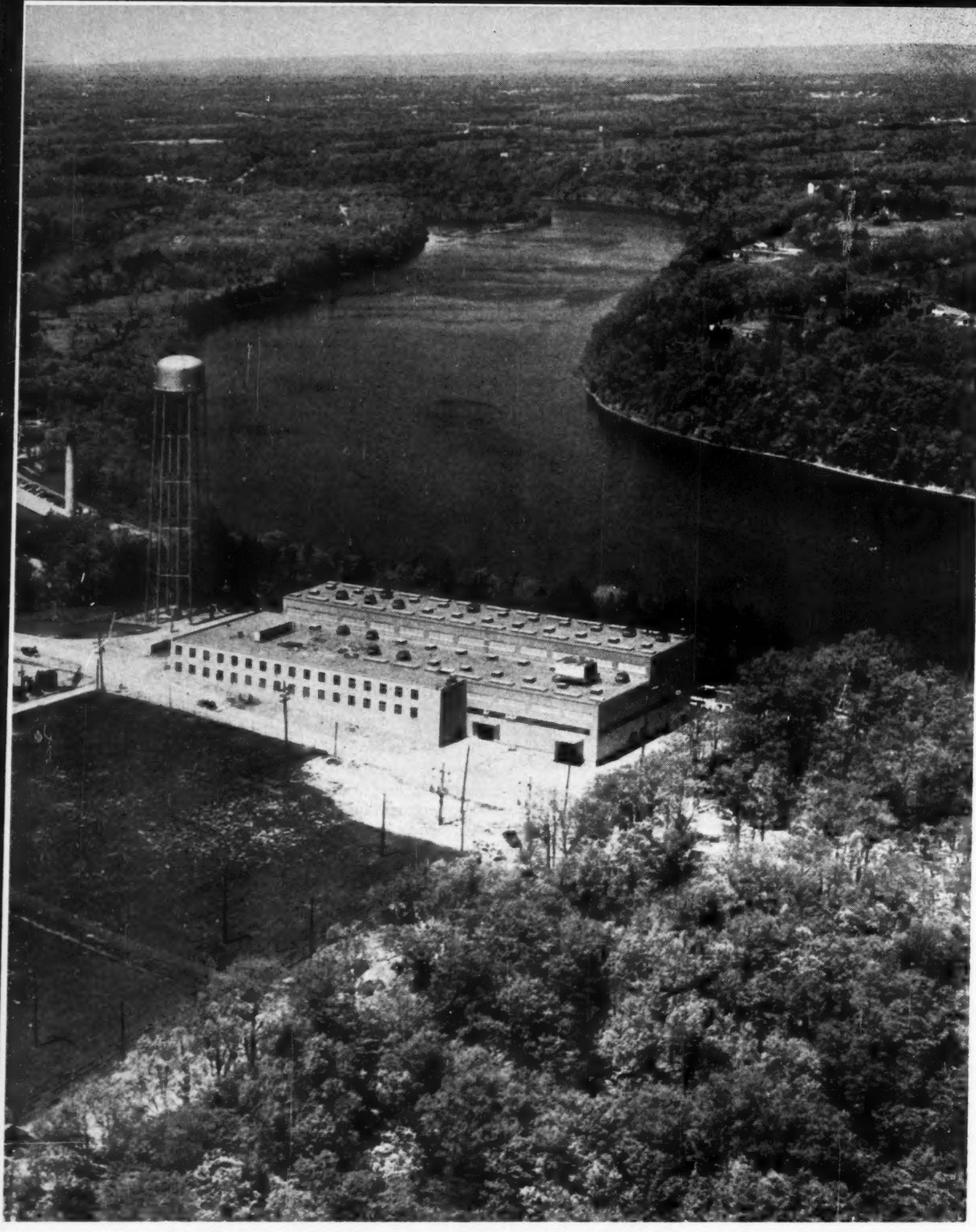

Aerial View of Metals and Ceramics Building . . .

. . . at the General Electric Research Laboratory. This new $5,000,000 research facility, which is located at The Knolls overlooking the Mohawk River near Schenectady, N. Y., was formally dedicated August 26, 1955. It is destined to provide new materials for the future—for applications ranging from faster rockets and atomic power plants to laborsaving kitchen equipment. See picture story, pages 816 and 817.

Editorial

MECHANICAL ENGINEERING

September, 1955, Vol. 77, No. 9 ♦ George A. Stetson, *Editor*

ASME Publications Program

By means of publications several objectives of The American Society of Mechanical Engineers are attained. The expense of these publications and of the services necessary to produce them constitute about two thirds of the total expense of operating the Society. Fortunately, publications produce enough income to offset the expense charged against them. Hence the dues of members, and other sources of income, can be utilized in carrying out other Society activities and objectives that are no less desirable and important.

ASME publications fall into two groups: (1) periodicals (Mechanical Engineering, Transactions, *Journal of Applied Mechanics*, and *Applied Mechanics Reviews*); and (2) nonperiodicals ("preprints" of papers for presentation at meetings; publications developed by ASME Code, Standardization, and Research Committees; books and pamphlets on special subjects; biographies; and the "Mechanical Catalog"). The current list of ASME nonperiodical publications contains about 275 separate items, and the ASME Order Department normally carries in stock preprints of about 500 current papers. In the calendar year 1954 Mechanical Engineering contained 1032 pages, Transactions 1424, *Journal of Applied Mechanics* 420, and *Applied Mechanics Reviews* 606.

These publications serve a threefold purpose:

(1) Technical information of a highly specialized nature is widely disseminated in Transactions, *Journal of Applied Mechanics, Applied Mechanics Reviews*, and in practically all of the nonperiodical publications.

(2) General-interest and review articles relating to technical subjects, management, education, economics, and the engineering profession, which have a broad appeal and serve to cross-fertilize information from one field of specialization to others, appear in Mechanical Engineering which is mailed to every member of the Society and about 3700 nonmembers.

(3) News of ASME and related organizations, the engineering profession, and current developments in mechanical engineering and allied fields of engineering and science also reaches all members through Mechanical Engineering.

Concerned as it is with mechanics, machinery, manufacturing, power, and transportation, the field of mechanical engineering has always been a broad one. Today that field is expanding rapidly as science and industrial civilization advance. Mechanical engineers are consequently becoming more highly specialized. Both of these facts are abundantly borne out by the results of the 1954 ASME Membership Survey Questionnaire reported in this magazine in March and April of this year. This breadth of field and the diversity of individual specialization of ASME members is reflected in the great extent and variety of the activities of the Society and in its publications program and creates the problem of keeping every member informed about them.

Free distribution of all ASME publications to every member is wasteful and too heavy a burden for the Society. Hence ASME utilizes a number of methods to notify members and the public of availability of its publications and where they may be found. About 15,000 copies of a catalog of publications are distributed annually in a variety of ways. Each new member receives a copy. In addition, another 15,000 copies are bound in "Mechanical Catalog." Exhibits of the publications are maintained at every national meeting and preprints of the papers being presented are offered for sale. ASME papers are indexed by the Engineering Index Service, Inc., and are filed and bound by the Engineering Societies Library. Depositories of Transactions are maintained all over the world and in every institution where there is an ASME Student Branch. A section of Transactions issued in January contains lists of all publications and all miscellaneous papers filed in the Engineering Societies Library, and indexes of Mechanical Engineering, Transactions, and *Journal of Applied Mechanics*. Reprints of this section are available.

By following the pages of Mechanical Engineering the reader can keep up to date on ASME publications issued. Tentative programs of national meetings and division conferences announce, with paper numbers when they are known, the papers to be presented. Reports of these meetings and conferences include lists of all available papers. Digests of these papers, with order form, appear monthly in the ASME Technical Digest Section. The contents of the current issue of Transactions is also printed every month. Other new Society publications are noted in ASME News Section as soon as they are published.

ASME members have reason to be proud of the publication program to which so many give generously of their time and energy. They must be constantly on the alert to improve and expand it, to keep it on a self-supporting basis, and to make use of the material it offers them in their professional activities.

Brass-Powder Structural Parts in Product Engineering—*An Evaluation*

Information for product engineers as to which powders can be pressed and sintered, what the specific design considerations are, what physical and mechanical properties can be expected, and where such parts can be employed

By G. L. Werley

Research Staff

The New Jersey Zinc Company

Palmerton, Pa.

The domestic production of metal parts from powder is not new. Oilless bearings, for example, have been pressed from powder with great success since the early 1920's. However, the currently expanding use of metal-powder structural parts is definitely in the new category, and product engineers are now seeking more basic information on the subject.

Practically all metals can be made into powders, but those most widely used for powder metallurgy today are iron, copper (largely mixed with tin to produce bronze), and brass. The latter metal, brass, was a late starter in the field of powder metallurgy and, consequently, the qualities of this powder for the pressing and sintering of structural parts are not so well known as those of some of the more firmly established metals. But the use of brass powders is increasing rapidly, and it should be of considerable interest to analyze why this is so.

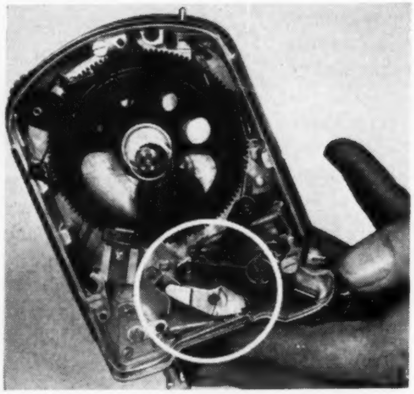

Fig. 1 Camera-shutter mechanism. Circled is brass-powder tripper flywheel.

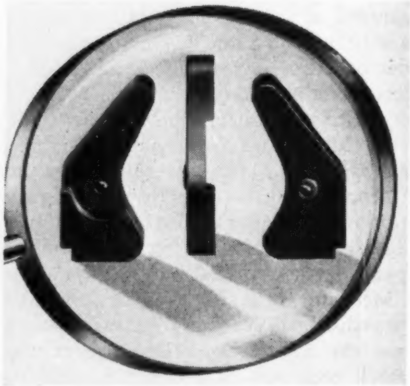

Fig. 2 Close-up of both sides of shutter-tripper flywheel for camera

Camera-Shutter Mechanism

As a start, consider an actual brass-powder application. Fig. 1 shows the shutter mechanism for the latest model of the Polaroid Land camera. Accurate control of the shutter is, of course, essential to the proper functioning of a camera, and a great deal of skill and ingenuity are concentrated in the design of the shutter mechanism. A vital part of this mechanism is the brass-powder tripper flywheel (circled in Fig. 1).

A close-up of the tripper flywheel from both sides, Fig. 2, reveals not only its irregular-shaped over-all

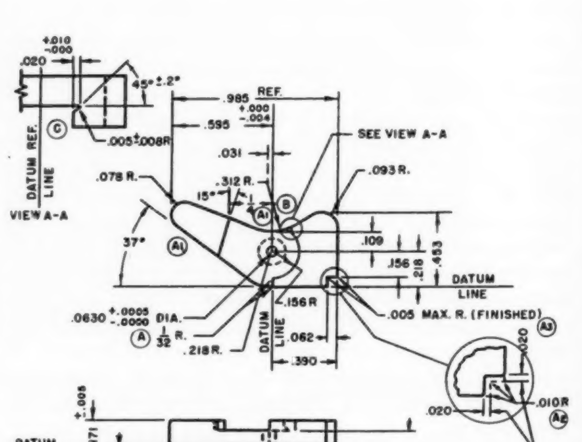

Fig. 3 Tolerances allowed for the shutter-tripper flywheel

Contributed by the Metals Engineering Division and presented at a joint session of the Metals Engineering and Machine Design Divisions at the Diamond Jubilee Spring Meeting, Baltimore, Md., April 18–21, 1955, of The American Society of Mechanical Engineers. Condensed from ASME Paper No. 55—S-39.

contour, but a depressed section on one side and a raised boss on the other. Also the part has a precisely located center hole. To make this part in brass by any process other than powder metallurgy would be difficult and, therefore, expensive. Certainly the part could be a machined extrusion, a precision casting, or a die casting, but in the final analysis, costs would have been quite high. As a brass-powder part, the odd contours and the center hole are formed in the one pressing operation, and the required tolerances, although close as indicated by Fig. 3, are attainable with no coining or machining operations.

Accomplishments of Brass-Powder Metallurgy

The fact that this part, or any structural part, can be produced successfully from brass powder, reflects the recent accomplishments of the metal-powder-fabricating industry. It was not long ago that the production of satisfactory brass-powder parts was considered to be extremely difficult, and few fabricators were willing to tackle the problem. The production procedures have now developed, however, to a point where the majority of fabricators can turn out excellent brass-powder parts, and consequently their fields of application are rapidly expanding.

During the Korean conflict more than 100 million of the brass-powder rotors, shown in Fig. 4, were produced successfully for the safety mechanism of artillery ammunition fuses, Fig. 5, and these parts gave an excellent account of themselves from a performance standpoint.

Incidentally, a spokesman for one of the arsenals recently stated that the use of these brass-powder rotors saved the Government at least 10 million dollars! The fact that a considerable number of new brass-powder ordnance parts are now specified is a further indication that this method of production has become firmly established. The fabricators, trained rapidly during wartime, are now in a position to apply all of this know-how to the high-speed production of a wide variety of small brass components for peacetime use.

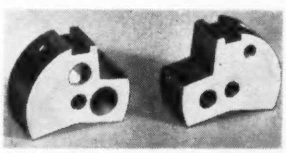

Fig. 4 Brass-powder rotors for fuse safety mechanism

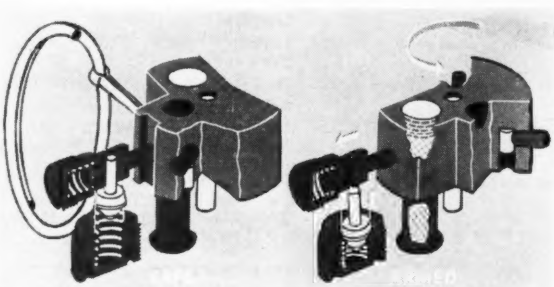

Fig. 5 The safety mechanism of artillery ammunition fuses

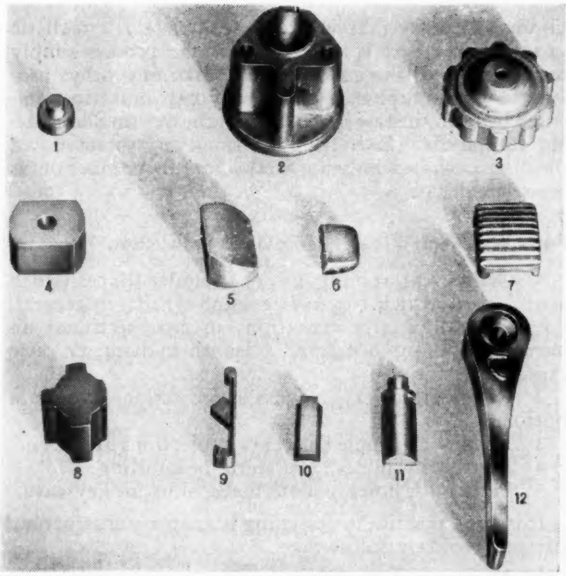

Fig. 6 Group of brass-powder parts in the under 4-in-diam size range. Largest is faucet handle at lower right.

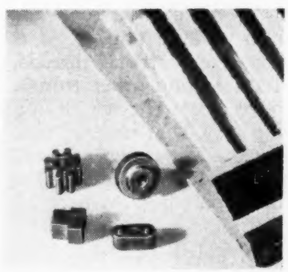

Fig. 7 Typical small brass-powder structural parts

Design and Production Factors

The product engineer who lacks adequate information concerning the capabilities of the powder-metallurgy process may find it difficult, in screening potential applications for brass-powder parts, to single out the basic elements which decide whether parts are "natural" designs, borderline cases, or impractical shapes for production by this method. Therefore some of the factors which have importance in the design and production of brass-powder structural parts follow.

The bulk of brass-powder compacts are in the under-4-in-diam size range, like the group shown in Fig. 6, in which the largest is the faucet handle at the lower right. Typical of the very small brass structural parts now being produced successfully are the four, Fig. 7, which are shown beside a book of matches for size comparison. The gear is about 0.2 in. diam. The T-shaped piece measures approximately $^1/_8$ in. across the top, $^1/_{10}$ in. at bottom, $^1/_4$ in. from the top to bottom, and $^1/_8$ in. in thickness; the bushing is $^1/_{10}$ in. thick and slightly less than $^1/_4$ in. diam. Smaller parts are possible, but the lower limit on minimum wall thickness or diameter is about 0.030 in.

While it is one of the principal virtues of the powder-metallurgy process that the parts so produced can be complex in shape to obviate the need for elaborate ma-

chining operations, it would be completely unrealistic to say that a part is a natural for the process simply because it is of intricate design. Like any other production method, powder metallurgy has limitations imposed by both the raw materials and the existing fabricating equipment. It is possible, however, to set down these basic shapes as being well-suited to production as brass-powder parts.

Parts Well-Suited to Brass-Powder Production

1 Cylindrical, rectangular, or irregular shapes which are relatively thick (up to 1 in.) and which, in general, do not involve large variations in cross-sectional dimensions and do not have a length-to-diameter ratio exceeding $2^1/_2$ to 1.

2 Parts with surface indents or projections on tops or bottoms.

3 Parts with simple flanges or projections at one end.

4 Parts with splines, gear teeth, or knurling.

5 Parts with holes, counterbores, slots, or keyways.

It is good practice in designing brass-powder structural parts to avoid the following:

1 Narrow or deep splines.

2 Feather edges.

3 Sharp corners at the junction of the flange and body on flanged parts and other stepped designs.

Normally it is impractical to produce powder parts having undercuts (annular grooves, screw threads, flanges at both ends, etc.) since, among other things, such parts are difficult to remove from the die cavity. It should be kept in mind, however, that undercutting and other machining operations, such as drilling and tapping, can be performed easily and economically on brass-powder parts, particularly on those which are formed with leaded brass.

Properties Obtainable

To provide comparative data which would point up the place of brass among other metals used in powder metallurgy, two authorities in this field recently prepared a series of charts comparing prealloyed leaded brass with a typical low-density bronze-bearing material, a high-density bronze structural alloy, a 90 iron, 10 copper mixture, and a normal-density plain iron. The prealloyed leaded brass was selected for comparison because it is the most widely used brass powder.

While a number of charts were prepared to reach the conclusions through an orderly process, the findings are summarized in Table 1. It can be seen that brass compares very favorably with the other materials from the standpoint of solid density obtained with normal forming pressures. The uniform shrinkage of brass during sintering permits accurate die design and results in a high-density product with minimum forming pressure. Note that brass is exceeded only by the iron-copper alloys from the standpoint of tensile strength, under comparable production conditions, and brass has much better elongation than the other commercial metals. It might be said that, when compacted and sintered under well-controlled conditions, brass-powder parts are generally comparable in physical and mechanical properties to brass castings. As related to wrought brass, the strength, hardness, and wear resistance of powder parts are more nearly equal to those of dead-soft annealed brass than to those of cold-worked stock. But the properties of parts made from wrought brass may be approached by repressing.

Brass-Powder Compositions

It may be of interest to analyze a few different brass-powder compositions to see the variations in mechanical properties which can be obtained in compacts pressed from such powders. Table 2 gives some figures for just seven of the many brass powders produced by the author's company. All of these powders can be pressed with high densities, but the mechanical properties vary as a

Table 1 Materials Comparison

Identification No.	Identification Name	Composition, per cent		Normal commercial properties: Dry density	Tensile strength	Elongation, per cent
A	80-20 Leaded brass	79 $19^1/_2$ $1^1/_2$	Copper Zinc Lead	7.4	25,000	10
B	Bearing bronze	$88^1/_2$ 10 $1^1/_2$	Copper Tin Graphite	6.4	12,000	1
C	Structural parts bronze	90 10	Copper Tin	7.0	18,000	$2^1/_2$
D	Iron-copper	90 10	Iron Copper	5.9	32,000	$^1/_2$
E	Plain iron	100	Iron	5.7	12,000	$1^1/_2$

Table 2 Horse Head Metal Powders—Comparative Properties

The following are average properties at the optimum sintering temperatures for compacts ranging from 87 to 91 per cent of the theoretical density using powder lubricated with 0.75 per cent zinc stearate.

	Horse head brass powders						
Powder number	1101	1104	1163	1178	1109	1110	1113
Nominal Composition:							
Cu	70	70	78.5	78.5	85	90	90
Pb	...	...	1.5	1.5	...	...	...
P	...	0.3	...	0.25	...	...	0.5
Zn	30	29.7	20	19.75	15	10	9.5
Optimum sintering temp, deg C	880	840	880	880	880	880	950
deg F	1615	1545	1615	1615	1615	1615	1740
Sintered densities corresponding to 87 to 91 per cent of the theoretical	7.3–7.6	7.3–7.6	7.5–7.8	7.5–7.8	7.6–7.9	7.6–7.9	7.6–7.9
Mechanical Properties							
Compacting pressure	30	28	28	31	28	29	27
Tensile strength	26800	31500	27400	28800	26800	22200	29200
Elongation	8	37	12	24	12	10	35
Rockwell H	80	68	81	71	74	65	55
Density as compressed	7.16	7.03	7.37	7.41	7.51	7.58	7.47
Change in length, per cent	−1.96	−2.58	−1.70	−1.65	−1.27	−0.83	−1.74
Change in weight, per cent	−1.94	−1.41	−1.39	−1.20	−1.11	−1.02	−1.13

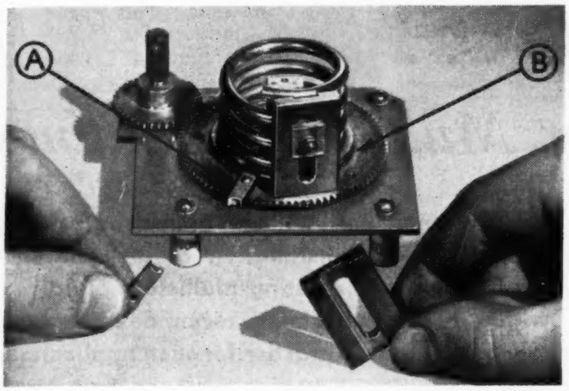

Fig. 8 Radio-transmitter driver grid. Parts A and B made from 90-10 brass powder.

result of the different powder compositions. The powders with phosphorus added have the highest ductility. When hardness in brass powders is important, 1101 and 1163 have superior properties. Powder 1110 shows the least shrinkage. Change in weight seems to vary with the amount of zinc present.

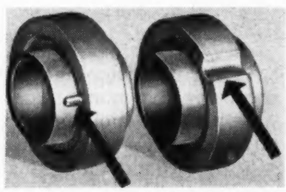

Fig. 9 Two views of a gear and cam hub

Applications

The electronics industry frequently finds brass to be a most desirable metal because of its strength, its corrosion resistance, its color, its high melting point, or its excellent bearing properties. A case in point is the radio-transmitter driver grid, Fig. 8, for which parts A and B are made from 90-10 brass powder to provide the required dimensional accuracy, strength, and corrosion resistance at low cost. The larger of the two brass-powder parts requires only the drilling and tapping of two end holes prior to plating for assembly. The alternative method of production would undoubtedly be extrusion from bar stock, entailing not only the drilling and tapping, but elaborate milling to form the slot and channel (with considerable scrap loss) and a cut-off operation as well. Production of the smaller part by brass-powder metallurgy involves only the drilling of one hole. If extruded, both ends of the part would have to be milled to achieve the required contours and a cut-off, as well as the drilling operation, would be necessary. The tolerances held in both of these brass-powder parts are of the order of ±0.005 in.

Two views of a gear and cam hub are shown in Fig. 9. These might be used in almost any field of manufacture. Were it not for the key and key notch (indicated by arrows), this part could be machined from bar stock with little difficulty. But these design details were essential to the performance of the part and would entail prohibitive machining cost if produced by conventional means. As it is, the hub is pressed from brass powder to its final shape and dimensions with no secondary operations required to place the part in service. The designers of this part stated at the time that "were it not for the powder-metal process, a different approach would have had to be taken at the design stage."

As a final example of successful application of brass-powder structural parts, consider one which is never far from our finger tips—the dial mechanism of the latest telephone handsets made by Western Electric for the Bell System, Fig. 10. Three parts perform the important function of controlling the rotational speed of the dial and these vital parts are made from brass powder, Fig. 11. They are the matching governor weights and the drive bar, in which close control of both weight and dimensional tolerances are imperative to efficient performance.

The powder-metallurgy process was easily the lowest-cost method of producing these parts. Although the shapes require relatively complicated tooling substantial savings over any alternative method result, because secondary operations are not needed to produce finished parts. Production rates of 1000 per hr per set of tools make for further economies.

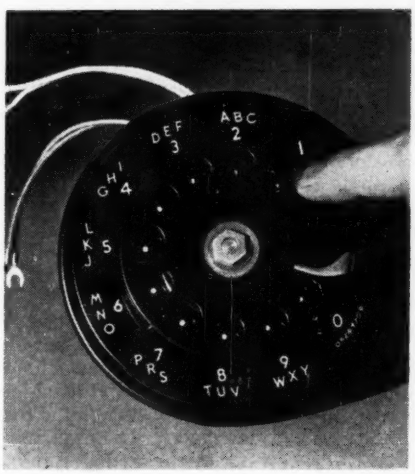

Fig. 10 Dial mechanism for latest telephone handset

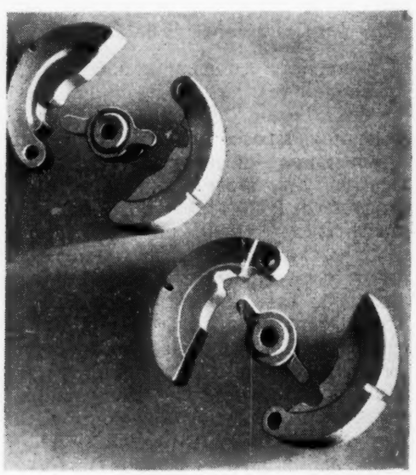

Fig. 11 Speed-control parts for dial made from brass powder

Conclusions

This is the story in brief of brass-powder metallurgy as it stands today and it is some measure of the importance of the process for the future. It remains only for the engineering fraternity to re-examine the thousands upon thousands of small brass parts now being produced by traditional means, to determine whether or not tradition is cheating industry out of lower production costs which are so vital to success todav in most fields of manufacture.

AIR CONDITIONING . . .

. . . *for Multistory Buildings*

A survey of pertinent problems influencing application and installation of air-conditioning for new and existing multistory buildings, with a discussion of more recent developments regarding modern practice for such applications

By P. B. Gordon

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Among the more interesting activities in the air-conditioning field of the past eight-year period are those concerned with the tall-building problem, particularly the multistory multiroom office building. The present active demand and future economic possibilities in the office-building air-conditioning field—for new and existing buildings—are providing the economic stimulus toward many improvements in methods.

Why Air-Condition Tall Buildings?

There has been much talk about the reasons for installing all-year air conditioning in tall buildings. Some of the talk concerns demand and trend factors. Other reasoning is based on justification factors. Year-round conditioning—meaning all-year climate control—for the large building moved from an occasional luxury application of the 1930's to a must situation now existing in many cities. Demand on the part of building tenants and their workers for modern standards of comfort heretofore never was important. As more buildings were conditioned, this demand factor became stronger. Personnel departments now find it difficult to acquire new employees for non-air-conditioned buildings when the prospective employee may choose employment in a conditioned building. Competition between conditioned rental buildings and nonconditioned rental buildings also accelerates this trend.

Beyond trend and demand factors, certain justification factors are of interest. A few that influence decisions regarding acceptance of complete air conditioning are the following:

1 Air conditioning permits the use of floor areas heretofore considered submarginal. By eliminating street noises and dust, it makes lower floors as acceptable as upper floors of tall buildings. Interior areas can be made acceptable for office use as well as the more preferred perimeter areas.

2 Air conditioning permits less expensive building floor plans. There is less need for narrow wings for light and ventilation.

Contributed by the Process Industries Division and presented at the Annual Meeting, New York, N. Y., November 28–December 3, 1954, of The American Society of Mechanical Engineers. Condensed from ASME Paper No. 54—A-265.

3 Air conditioning permits high-occupancy concentration or maximum utilization of floor space.

4 Air conditioning permits high-lighting intensities now favored for modern building design.

5 Air conditioning makes available a controllable environment tending toward improved worker efficiency and better housekeeping.

Changes in the Art

The development of tall-building all-year air conditioning has been rather rapid. The history of the methods used can be broken down into two general time periods: (1) Methods in common use before the middle 1930's, and (2) the more popular methods developed since the middle 1930's.

The early period approach to the occasional problem of providing air conditioning for a multistory building used the methods available at that time to provide conditioning for industrial plants, movie houses, department stores, and the like. These methods involved large-space techniques, handling large quantities of conditioned air introduced directly into the spaces.

During this early period, the refrigeration generally was provided by an ammonia or carbon-dioxide plant, though centrifugal machines became popular during the latter part of this period for loads over 100 tons refrigeration effect. These plants circulated brine or chilled water to the air-handling apparatus to provide the cooling effect. The development of compact lightweight refrigerating equipment, with simple automatic refrigerant controls and direct-expansion refrigeration equipment, occurred during the early 1930's.

The cooling and dehumidifying of air during the early period involved use of spray dehumidifier (air washer) or pipe-coil bunker equipment. Lightweight finned heat-transfer surface designed for circulation of chilled water or direct expansion of Freon-12 was not available until the early 1930's.

The important changes of the later period (since the mid-1930's) that influenced the application of air-conditioning to tall buildings are as follows:

1 *Changes that have improved the distribution of air-conditioning effect.* These provide more effective distribution of conditioning effect to remote spaces—self-

contained units, local terminal air-handling units supplied by all-air single ducts, all-air hot and cold dual ducts, or combined air and circulating-water systems.

2 *Changes that have improved refrigerating compressor design.* Advances during recent years have tended toward higher speeds resulting in more compact units and smoother-running agreement. The Freon development of the early 1930's and the more recent changes involving Freon-22 and similar refrigerants are lessening the weight and size of refrigeration apparatus, that is, more refrigeration performance per pound of refrigeration equipment.

3 *Changes that made the use of steam for refrigeration power more economic.* Steam-turbine-driven centrifugal apparatus was used during the 1920's and steam-jet water-vapor refrigeration apparatus enjoyed a short period of popularity during the early 1930's. In recent years, modern absorption refrigeration equipment has become available. These machines were developed to use steam at low operating pressures with good economy. At the present time, turbine-driven centrifugal machines and modern absorption machines are being used.

4 *Changes that have integrated ceiling construction with air-conditioning distribution.* Modern building design has tended toward increased interest in the complete ceiling that provides for over-all environmental control—acoustic treatment, modern lighting, and thermal environment.

Distribution of Air-Conditioning Effect

The most important application problem of multistory air-conditioning concerns the most feasible method (as to engineering, economics, and practicality) of providing for the distribution of air-conditioning effect to the multistories, generally on a multiroom, multizone basis. Many other problems such as the best method of supplying refrigeration, the location of the cooling tower, choice of steam or electric power for refrigeration plant are all important, but the problem requiring the most study and influencing the largest amount of over-all building investment will revolve around "the manner of distributing the air-conditioning effect."

At present, the more popular methods may be summarized as follows:

1 Unitary methods

Room Units. Air-cooling refrigeration units of $^1/_3$-ton to $1^1/_2$-ton capacity with an air-cooled condenser. Units may be provided with hot-water or electric air heaters, but are used generally as a supplement to radiator heating.

Self-Contained Units. Self-contained air-cooling packages of 2-ton to 25-ton capacity that include refrigeration apparatus with fans, air filters, heating coils, and automatic controls. Generally used to serve small office areas or single office floors. Condensers are usually water-cooled though larger sizes may include an evaporative condenser. Steam or hot-water coils are included generally for air-heating and dehumidification control.

2 Central-System Methods

(Usually involves a central-system refrigeration plant distributing chilled water to apparatus rooms or local terminal units. Steam or hot water also furnished to central rooms or local terminal units for heating.)

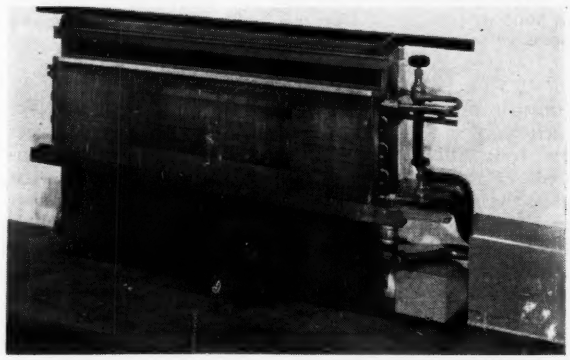

Fig. 1 Three central-system methods of providing for perimeter room conditioning on a modular basis. Top photo shows a Carrier Corporation high-velocity unit. A York Corporation high-velocity unit is shown in center. Bottom view shows a Buensod-Stacey, Inc., high-velocity dual unit.

A All-Air Distribution

Single Duct—Low-Velocity Distribution. These systems may be arranged with central apparatus rooms serving an entire building or section of a building, or with local apparatus rooms serving smaller areas. When room or zone

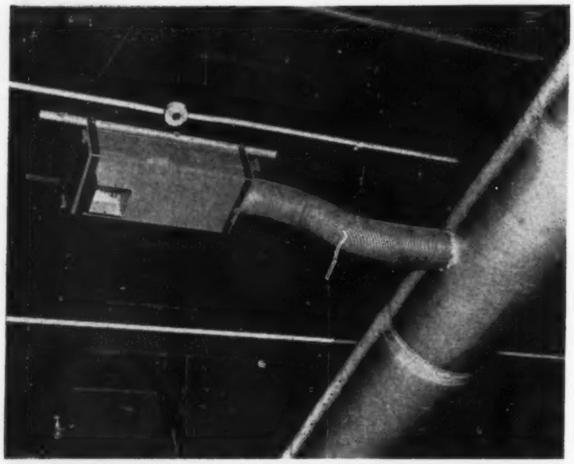

Fig. 2 Barber-Colman Company high-velocity air-supply unit. A single duct system—it handles conditioned air at velocities of 3000 to 4000 fpm. Unit is used to reduce air velocity and pressure as well as to attenuate air noise.

controls are required, air distribution may be supplemented by either zone reheaters, individual room reheaters, zone volume controls, individual room volume controls, or a combination of these under control of room or zone thermostats. Low-velocity ducts are classified generally as those constructed in accordance with ASHAE Recommended Gages and Construction, and operating at duct velocities of 800 to 2000 fpm.

Single Duct—High-Velocity Distribution. At present systems designated as high velocity distribute air at velocities ranging from 2500 to 4000 fpm, and usually with large temperature differentials for cooling, 30-deg temperature difference between supply air and room air rather than the more usual 15 to 20-deg temperature difference. These high air velocities and greater temperature differences reduce duct sizing. These systems require air-supply units capable of satisfactorily handling air at these high-temperature differentials and are used in conjunction with sound attenuating devices to attenuate air and fan noise and combined with control valves for temperature control.

Dual Duct—Low-Velocity Distribution. These systems distribute air to the conditioned spaces through two parallel ducts operating at differing temperature levels. Air is supplied to the individual spaces through a mixing arrangement with the quantity of hot and cold air used controlled by variable dampers.

Dual Duct—High-Velocity Distribution. These systems are somewhat similar to dual-duct low-velocity systems. Smaller ducts result from high-velocity distribution and larger supply air-temperature differentials. This method uses ceiling diffusers with sound-attenuating mixing and control boxes or may supply mixing boxes and air diffusers designed for "under-window" installation. Control is provided by regulation of hot versus cold dual-duct air quantities.

B Terminal Units With Primary-Air Distribution

Induction Unit—Low Velocity. All cooling provided by primary conditioned air transported through duct system at high-temperature differences. Induction units generally are provided for each room module and equipped with either steam or hot-water coils to heat the induction air for reheat control in summer and for building heating in winter. Control can be provided by means of air damper or coil valve.

Induction Unit—High Velocity. Unit located in each module uses primary-air supply from central source with induction arrangement to recirculate room air. Primary air supplied to unit must satisfy ventilation and dehumidification requirements, provide power for induction effect, and provide for selective control flexibility. Water coil is supplied by central distributing system providing cooled or heated water with both primary-air temperature and water temperature under control to make available at each module selective control flexibility.

Fan Coil Unit With Primary Air. Units are located within each module and include water coil, air filter, fan, and motor. Primary air supplied to fan coil unit may be distributed by means of low-velocity or high-velocity ducts. Primary air must satisfy ventilation and dehumidification requirements and provide for selective-control flexibility.

Terminal Units Without Primary Air. Fan coil units are installed without direct connection of primary air to units, so that units simply recirculate room air. Primary air may be supplied to the conditioned spaces by means of separate duct system for ventilation and dehumidification requirements and to permit selective control.

Another modification involves drawing fresh air for ventilation directly into terminal units through building wall slots.

C Panel-Type Ceilings in Combination With Air Distribution

Several panel ceiling arrangements are available that integrate complete ceilings with metal panels used for heating and cooling. One arrangement uses circulating water to heat or cool panel with another arrangement using the ventilation air as the panel heating or cooling medium. Either arrangement utilizes panels to handle a fraction of the sensible heating or sensible cooling load with the ventilation air supplied directly (or through panel for air panels) handling the ventilation and dehumidification requirement as well as part of the direct load.

What Kind of System to Use?

Any pertinent analysis to determine most feasible method to be used must review those considerations that influence space-planning, installation, and operating problems, and over-all costs, such as the following:

Loss of Building Floor Space. Location and size of apparatus rooms required; floor space used by ducts and piping; ceiling space used by ducts and piping.

Most Effective Manner of Transporting Btu's. Use of air ducts versus water piping, or use of thermal circuits (air and water) versus one thermal circuit (air); use of high-velocity ducts versus low-velocity ducts; use of high-temperature differential versus normal-temperature differential.

Flexibility and Control. Methods of providing for selective room or module control; handling shifting perimeter load; handling change-over from cooling to heating; providing for humidity control.

Air Cleaning. Effectiveness and location of fresh-air filters and return-air filters; arrangement to service filters.

Noise and Vibration. Economy of high-velocity distribution versus cost of adequate sound-attenuating devices; noise level in occupied spaces with system in operation compared with background noise level.

Servicing and Operating Problems. Amount and location of apparatus requiring routine maintenance, inspection, and repairs; coil-cleaning requirements; economies of filter operation; stability of automatic devices and controls.

Economy of Operating Refrigeration Plant. Quantity of fresh air supplied for ventilation; quantity of primary air supplied to remote terminal units; methods of providing cooling by use of outdoor air during midseason; excessive dehumidification (and additional tax on refrigeration load) resulting from systems using high-temperature differential with low air quantity.

Installation Complications for Existing Buildings. Adequacy of existing perimeter heating system; method and scheduling for removing heating system and installing new perimeter system; extent of disturbance to building occupants (and resultant cost of overtime operations).

In general, three major questions will influence an evaluation of the foregoing considerations.

1 How important is the "building skin" load, and is it necessary to separate the perimeter area from the interior area?

It is interesting to note that the interior spaces of a modern building require cooling at all times due to the constant load created by the occupants and lighting, and the absence of exposure load.

2 How important is "control," that is, must there be selective room or modular control, or will zone or area control be acceptable? How flexible must the system be to provide the desired control and to meet automatically the changing load?

The changing-load consideration and the inherent flexibility and controllability of the system are of extreme importance at the time of weather change, i.e., shift from a heating day to a cooling day, or a heating morning to a cooling afternoon. This consideration is also of importance when cooling is required on one side of the building due to sun effect (plus lights and occupancy) while heating is required on other sides due to low outside temperature.

As more and more people live and work in fully air-conditioned buildings, the demand for more accurate control becomes more pertinent. For the early systems, often an approximation of control was acceptable as it was then believed that any summer air conditioning was better than none. Today, and more so in the future, this concept will no longer hold. The modern tendency is toward accurate control at all times.

3 How much building space will the proposed system use for the installation of ducts, piping, equipment, and the rest?

The entire problem of space, effective distribution, flexibility, and control is tied in with high-velocity versus low-velocity distribution, all-air versus air-water distribution, and low versus high temperature differential distribution.

To justify any small duct systems with possible saving in space, construction costs, and duct and insulation costs, one must accept higher costs for diffusers, controls, valves, mixing boxes, and fans.

The pressure of these problems joined with the marked increasing demand in recent years for conditioning of tall buildings have forced the air-conditioning industry to provide increasingly more effective methods and devices.

It is believed that the trend in the future will be toward the improved system capable of the utmost in performance and away from the makeshift or "get-by" system. As a larger number of people become accustomed to fully conditioned environment, the greater the demand will be for systems capable of providing continuously high-quality performance.

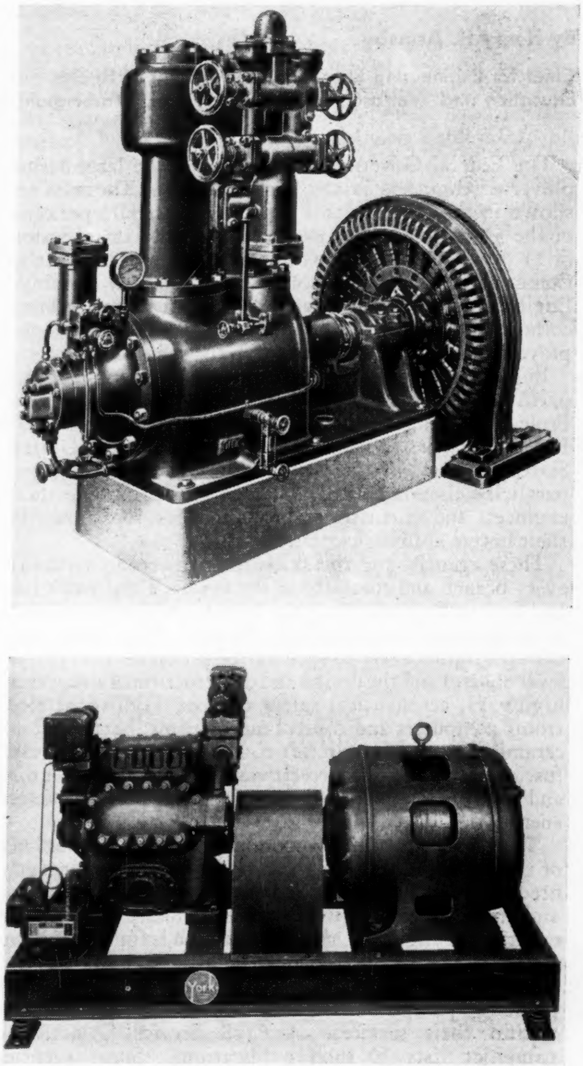

Fig. 3 Refrigeration machines—illustrative of changes in design of reciprocating refrigeration apparatus during the past quarter century to lessen weight and to reduce vibration. (Courtesy of York Corporation.)

Engineers and Scientists in Government . . .

An answer to the question of what opportunities and rewards exist in Government service

By Henry H. Armsby

Chief for Engineering Education, Department of Health, Education and Welfare, Office of Education, Washington, D. C.

The Federal Government as a unit is the largest employer of engineers in the United States. The number shown in the tables in this paper constitutes 13 per cent of the 543,000 engineers enumerated in the 1950 census, or 11 per cent of the 633,000 estimated for 1953, by the Commission on Human Resources and Advanced Training. Engineers in 1951 constituted 8 per cent of all white-collar Federal workers or 3 per cent of all Federal employees. In 1954 these ratios were the same.

Engineers in Federal service have opportunities to participate in challenging work of vital importance. Professional engineers are employed by more than 30 Federal agencies in installations throughout the United States. Several of these provide research facilities unparalleled elsewhere, and all assist and encourage their engineers and scientists to grow and develop as fast as their native abilities permit.

These agencies use the skills of engineers in virtually every branch and specialty in the field. Their work has had far-reaching effects on the health, welfare, standards of living, and economy of the Nation. They have contributed significantly to such varied problems as typhoid-fever control and the design and construction of structures, highways, aeronautical safety devices, high-speed electronic computers and control mechanisms, heat-resistant ceramic coatings for aircraft components, the proximity fuse, guided missiles, aircraft warning systems, the atom and hydrogen bombs, and the industrial uses of nuclear energy.

The Government needs more engineers in all branches of the profession, although at present the most urgently needed are electrical, mechanical, ceramic, chemical, and civil engineers. While there are many openings for experienced engineers, the greatest need is for men just entering the profession. Many Federal agencies have active recruiting programs for young engineers and have published pamphlets outlining engineering opportunities within their services. A Civil Service Commission pamphlet lists 30 such publications. Some agencies recruit engineering students to serve in trainee positions during vacations, which may lead to appointments at the professional level after graduation.

The Government Salary Scale

Government workers are organized into 18 grades, designated Government Service 1 to 18, and generally abbreviated as GS-1 to GS-18. Table 1 shows the range of annual salary in each of these grades. In the first column the salaries are those which were in effect prior to June 30, 1951. The second column is the new salary scale which took effect on that date. The third column is the new salary scale effective March 1, 1955.

Table 1 Salary Ranges for Government-Service Grade Levels

Government service grade	Dollars per annum: Prior to 6/30/51	Effective 6/30/51	Effective 3/1/55
GS-1	2200–2680	2500–2980	2690–3200
GS-2	2450–2930	2750–3230	2960–3470
GS-3	2650–3130	2950–3430	3175–3685
GS-4	2875–3355	3175–3655	3415–3925
GS-5	3100–3850	3410–4160	3670–4480
GS-6	3450–4200	3795–4545	4080–4890
GS-7	3825–4575	4205–4955	4525–5335
GS-8	4200–4950	4620–5370	4970–5780
GS-9	4600–5350	5060–5810	5440–6250
GS-10	5000–5750	5500–6250	5915–6725
GS-11	5400–6400	5940–6940	6390–7465
GS-12	6400–7400	7040–8040	7570–8645
GS-13	7600–8600	8360–9360	8990–10065
GS-14	8800–9800	9600–10600	10320–11395
GS-15-18	10000–14000	10800–14800	11610–14800

Grades 1 to 4 are subprofessional grades. A bachelor's degree in engineering or equivalent technical experience qualifies for appointment at the GS-5 level, while a master's degree or 6 months of professional experience is required for the GS-7 level. (Grades 6 and 8 are not used for professional positions.) A doctor's degree or $2^1/_2$ to 3 years' experience qualifies for GS-11 positions.

Many agencies operate training programs under which young engineers are promoted from GS-5 to GS-7 upon satisfactory completion of 6 months' training or even less under student-trainee programs. Grades 5 to 8 have been grouped together in the studies of distribution by grade levels which follow, as what might be called the beginning grades for professional personnel.

Grades 9 to 12, inclusive, cover the positions which may be called full-fledged professional positions in government, but not policy making. Advancement to GS-9 is possible after 12 months of satisfactory service at Grade 7, and those who prove worthy can be advanced to Grade 11 after one year in Grade GS-9 and to Grade GS-12 after one year's experience in the GS-11 grade.

Grades 13 and 14 are section chiefs, division directors, and so on. These are subpolicy makers, who usually

Condensed from an address presented at the Diamond Jubilee Spring Meeting, Baltimore, Md., April 18–22, 1955, of The American Society of Mechanical Engineers.

attain their positions after a considerable number of years of governmental or private service. Grades 15 to 18 are the so-called "super grades," which cover agency chiefs, subcabinet members, and other real policy-making positions. Some of these are political appointments.

Promotion from one grade to another is not automatic. It depends upon experience, assignment of greater responsibilities, and the occurrence of vacancies. However, within any grade satisfactory service leads to automatic within-grade salary step increases at intervals, from $125 each year in the lower and middle grades to $200 or $250 every 18 months in the higher grades.

Governmental Versus Industrial Salaries

A study made by the Civil Service Commission in August, 1953, contains some interesting comparisons of salaries in government with those in industry for each year from 1949 to 1952. For persons who are graduated in the same year, private salaries are in general above governmental, especially in the beginning years and at the higher grades, the differential running to as much as 30 per cent for those with 20 years of experience.

The same is true of research and development scientists and engineers with doctor's degrees. For example, the new doctor, 3 years after receipt of his bachelor's degree, in the Federal Government in 1952 received a monthly salary of $526, while his classmate in industry received $546. For those 10 years out of college and holding the doctor's degree, the average salary in Federal Government was $575, in private industry $625. For those 20 years out of college the monthly salaries were: Federal Government—$672, private industry—$795.

Because of the shortage of engineers and the competition of industrial entering salaries, the Civil Service Commission has authorized Federal agencies to make appointments to engineering positions in Grades GS-5 and 7 at rates above the minimum for the grade.

Numbers and Distribution of Engineers in Government

Fortunately the author has been able to secure a large amount of data, some not yet published, as to the number of engineers and scientists in government, and their distribution by GS-grade levels and by Federal departments. These data are condensed into Tables 2 to 6, inclusive.

The source of the statistics for the years 1947 and 1951 is Bulletin No. 1117 of the U. S. Department of Labor, entitled "Federal White-Collar Workers, Their Occupations and Salaries." This bulletin was prepared jointly by the Bureau of Labor Statistics and the U. S. Civil Service Commission, and contains extensive data for the two dates June 30, 1947 and June 30, 1951. The bulletin contains a warning that the figures for the two years are not strictly comparable but conversations with persons in these agencies leads to the belief that any errors

Table 2 Full-Time White-Collar Workers in Selected Occupations Employed by Federal Government in Continental United States[a]

Occupation	Number in thousands June 30, 1947	June 30, 1951	Aug. 31, 1954	Percentage (1947 = 100%) 1951	1954
Total full-time white-collar workers	680.1	905.9	843.1	133	124
Engineering	51.1	71.3	68.8	139	135
Physical sciences	12.0	21.6	20.1	183	167
Biological sciences	17.8	26.0	28.3	145	159
Mathematics and statistics	10.4	18.3	16.9	180	163
Legal and kindred	29.1	29.1	23.6	100	81
Education	5.2	8.2	10.6	160	204
All Federal employees	1,856.3	2,309.1	2,156.9	124	116

[a] Sources: 1947 and 1951 from U. S. Dept. of Labor Bulletin No. 1117; 1954 from preliminary figures (subject to correction) in Civil Service Commission study not yet published.

Table 3 Full-Time Engineers Employed by Federal Government in Continental United States[a]

Occupation	Number in thousands June 30, 1947	June 30, 1951	Aug. 31, 1954	Percentage (1947 = 100%) 1951	1954
All engineering	51.1	71.3	68.8	139	135
Subprofessional	18.7	26.2	25.5	140	136
Professional	32.4	45.1	43.3	139	134
Subprofessional	18.7	26.2	25.5	140	136
Engineering aid	9.4	11.2	9.3	119	99
Engineering draftsman	9.3	15.0	16.2	161	174
Professional engineering	32.4	45.1	43.3	139	134
Civil	10.5	13.9	12.6	132	120
Electrical and Electronic	3.4	10.1	9.1	298	268
Mechanical	4.1	6.7	5.8	163	141
Naval Arch. and Marine	1.4	1.9	1.9	135	135
Aeronautical	2.4	1.7	1.4	71	58
Chemical	0.5	1.1	1.0	220	200
Mining and Petroleum	0.3	0.6	0.5	200	166
Others	9.8	9.1	11.0	93	113

[a] Sources: 1947 and 1951 from U. S. Dept. of Labor Bulletin No. 1117; 1954 from preliminary figures (subject to correction) in Civil Service Commission study not yet published.

Table 4 Full-Time White-Collar Workers in Selected Occupations Employed by Federal Government in Continental United States[a]

Occupation	Year[b]	Thousands of workers	Percentage distribution by government-service grade levels: GS 1–4	GS 5–8	GS 9–12	GS 13–14	GS 15–18	Not stated
Total full-time white-collar workers.....	1951	905.9	51.4	25.6	16.7	2.7	0.4	3.2
	1954	843.1	48.4	24.4	21.3	4.2	0.8	0.9
Engineering.........	1951	71.3	15.2	33.2	41.2	6.9	0.5	3.0
	1954	68.8	10.7	25.4	49.6	9.7	1.0	3.6
Physical sciences.....	1951	21.6	10.4	39.5	38.5	7.6	1.2	2.8
	1954	20.1	9.4	29.3	47.0	11.1	1.9	1.3
Biological sciences...	1951	26.0	26.8	45.5	21.9	2.7	0.3	2.8
	1954	28.3	27.0	42.9	26.4	3.0	0.4	0.3
Mathematics and statistics..........	1951	18.3	51.6	32.3	12.6	2.6	0.3	0.6
	1954	16.9	40.5	37.2	18.4	3.3	0.6	[c]
Legal and kindred....	1951	29.1	16.7	34.8	36.6	9.7	2.0	0.2
	1954	23.6	16.6	36.4	33.4	10.3	3.0	0.3
Education...........	1951	8.2	0.0	70.0	25.8		0.2	0.1
	1954	10.6	1.6	59.6	34.3	4.2	0.3	[c]

[a] Sources: 1947 and 1951 from U. S. Dept. of Labor Bulletin No. 1117; 1954 from preliminary figures (subject to correction) in Civil Service Commission study not yet published.
[b] June 30, 1951, and August 31, 1954.
[c] Less than 0.05 per cent.

introduced by this noncomparability are very slight, and do not affect the over-all picture.

A similar study was made of employment on August 31, 1954. This is now being tabulated at the Civil Service Commission and will not be released for some months. However, through the kindness of some friends in the Commission and in the Bureau of Labor Statistics, the author was granted a "scoop" by being permitted to examine the work sheets of this study and to extract such figures as he cared to use, with the warning that the figures for August 31, 1954, are preliminary and subject to correction, and that certain features of the study make these figures not strictly comparable with those in the earlier study. However, here again it is believed that any errors are small and do not affect the general over-all picture.

White-Collar Workers in Government

The total number of white-collar workers in the Federal Government on June 30, 1947, June 30, 1951, and August 31, 1954, is shown in Table 2, together with the numbers in the professional fields of engineering, physical sciences, biological sciences, mathematics and statistics, legal and kindred, and education. The last two fields are included as matters of general interest, and by way of contrast with the first four fields, in which it is believed engineers are most directly interested. The total of all Federal employees is added, simply for comparison.

The last two columns of this table express the 1951 and the 1954 numbers in each field as percentages of the 1947 number for the same group.

All groups were larger in 1951 than in 1947 except the legal and kindred group, which remained the same size. The white-collar group grew more rapidly than total Federal employment, and all the professional groups listed, except legal and kindred, expanded more rapidly than the entire white-collar group, engineering by the smallest margin. From 1951 to 1954 the biological sciences group expanded by an additional 14 per cent, and education by 44 per cent, while all other groups declined in size, although all but legal and kindred still had more workers in 1954 than they had in 1947. Engineers declined 3 per cent, while all white-collar workers were declining 7 per cent.

In Table 3 the engineering group which is shown in the second line of Table 2 has been broken down into two subdivisions of subprofessional engineers and eight subdivisions of professional engineers. The ratios from 1951 to 1954 for the subprofessional and professional engineers are practically the same as for all engineers, but there are sizable differences between the ratios for the two subdivisions of the subprofessional group and among the eight subdivisions of the professional group.

All the subdivisions of professional engineering listed expanded from 1947 to 1951, except aeronautical, which declined by nearly 30 per cent. Electrical and electronic showed much the greatest rate of growth, with chemical second, and mining and petroleum third.

From 1951 to 1954 all groups declined except naval architecture and marine, in which there was no change. All groups had more workers in 1954 than in 1947, except aeronautical, which had only 58 per cent as many. In percentage increase over 1947, the same three groups ranked first, second, and third as between 1947 and 1951.

Distribution by Salary Level

The total white-collar workers and those in the six professional groups discussed earlier are broken down according to their percentage distributions by Government Service grade levels in Table 4. It can readily be seen that there was a general decrease in the percentages of white-collar workers in Grades 1 to 8, and increases in Grades 9 to 18. This is probably due to promotions and to reduced recruiting of new personnel at the lower levels.

Column 9 in this table shows the number of positions which in the two reports were listed as "not specified." This means that the agencies who reported these persons did not specify their grades. How they should be distributed among the 18 grades is probably any-

Table 5 Full-Time Engineers Employed by Federal Government in Continental United States[a]

Occupation	Year[b]	Thousands of workers	Percentage distribution by government-service grade levels: GS 1–4	GS 5–8	GS 9–12	GS 13–14	GS 15–18	Not stated
All engineers	1951	71.3	15.2	33.2	41.2	6.9	0.5	3.0
	1954	68.8	10.7	25.4	49.6	9.7	1.0	3.6
Subprofessional	1951	26.2	41.0	49.3	6.8	0.3	0.1	2.5
	1954	25.5	29.0	53.0	13.4	1.6	0.4	2.6
Professional	1951	45.1	0.0	23.8	61.1	10.7	0.8	3.6
	1954	43.3	0.0	9.0	70.8	14.6	1.4	4.2
Civil	1951	13.9	0.0	22.9	62.2	9.5	0.7	4.7
	1954	12.6	0.0	11.0	72.1	11.5	0.8	4.6
Electrical and Electronic	1951	10.1	0.0	26.2	59.8	8.1	0.5	5.4
	1954	9.1	0.0	7.7	73.6	11.4	0.7	6.6
Mechanical	1951	6.7	0.0	28.3	62.3	6.5	0.3	2.6
	1954	5.8	0.0	7.6	78.0	10.0	0.5	3.9
Naval Arch. and Marine	1951	1.9	0.0	22.0	68.0	9.6	0.4	0.0
	1954	1.9	0.0	8.9	78.8	11.6	0.7	0.0
Aeronautical	1951	1.7	0.0	19.3	57.2	20.3	1.3	1.9
	1954	1.4	0.0	3.8	60.7	32.2	3.3	0.0
Chemical	1951	1.1	0.0	28.2	52.5	11.3	1.2	6.8
	1954	1.0	0.0	10.0	62.5	18.4	2.3	6.8
Mining and Petroleum	1951	0.6	0.0	14.3	60.6	21.5	3.5	0.1
	1954	0.5	0.0	5.0	67.0	22.6	5.0	0.4
Others	1951	9.1	0.0	20.5	61.0	16.0	1.6	0.9
	1954	11.0	0.0	9.6	63.8	20.7	2.7	3.2

[a] Sources: 1947 and 1951 from U. S. Dept. of Labor Bulletin No. 1117; 1954 from preliminary figures (subject to correction) in Civil Service Commission study not yet published.
[b] June 30, 1951, and August 31, 1954.

Table 6 Professional Personnel Employed by Federal Government in Continental United States, August 31, 1954[a]

Occupation	Total number[b]	Occupational distribution in selected agencies[b]: Dept. of Defense	Veterans Admin.	Dept. of Agric.	Dept. of Interior	Dept. of Commerce	Dept. of HEW	Other agencies
All professional	161.9	62.4	30.9	19.1	12.8	6.9	6.6	23.1
Engineering	43.1	29.7	0.3	1.7	4.6	2.1	0.3	4.3
Physical sciences	19.8	9.3	0.3	1.1	3.2	2.9	0.6	2.5
Biological sciences	16.4	0.9	0.2	12.9	1.6	[c]	0.6	0.1
Mathematics and statistics	4.9	3.3	0.1	0.4	[c]	0.4	0.2	0.5
Legal and kindred	10.1	1.2	2.6	0.2	0.3	0.1	0.1	5.7
Education	7.2	4.5	0.6	[c]	1.6	[c]	0.3	0.2
Others	60.6	13.5	26.8	2.9	1.5	1.4	4.7	9.8

[a] Source: From preliminary figures (subject to correction) in Civil Service Commission study not yet published.
[b] In thousands; detail may not add to totals because of rounding.
[c] Less than 0.05 per cent.

body's guess. They are listed for information and to give some idea of what the possible margin of error in the distributions may be.

Table 5 again takes the engineering numbers out of the preceding table and breaks them down into the same subdivisions which were shown on the previous breakdown of engineers. It will be noted that in the professional group there are no workers in Grades 1 to 4, the subprofessional grades. The decreases in the percentage of workers in Grades 5 to 8 are much more pronounced for the professional engineering groups than for the general groups shown in Table 4, as are also the increased percentages in the higher grades, especially in aeronautical engineering. It will be recalled that this group had the greatest decline in total number of persons from 1951 to 1954, and is the only professional engineering group to show a decline in total numbers from 1947 to 1954.

Distribution by Federal Agencies

Table 6 shows the distribution of a group designated as "professional personnel" by the Civil Service Commission in the study of August, 1954. This group cannot be compared directly with any of the preceding groups, although it does not differ greatly from the white-collar workers if Grades 1 to 4 are omitted. However, no real comparison with other groups is possible, and this table is presented simply to give an over-all idea of the distribution of professional personnel in the same fields we have been considering among the six agencies which use the largest numbers of engineers and scientists-

RIGIDITY—
The Unknown Cost-Reduction Factor

Greater rigidity in inspection gages, manufacturing equipment, and the parts themselves is necessary for cost reduction and improved quality

By C. A. Bierlein

Director of Inspection and Test
Cleveland Diesel Engine Division
General Motors Corporation, Cleveland, Ohio. Mem. ASME

THE modulus of rigidity for steel is about 11,500,000 psi. The modulus of rigidity for metals is about $^4/_{10}$ of the modulus of elasticity, so that for all practical considerations, the rigidity of metals is directly proportional to the modulus of elasticity. The following simple formula will serve as a refresher on this point

$$\text{Modulus of rigidity (for steel)} = 30{,}000{,}000/2(1 + 0.3) = 11{,}500{,}000 \text{ psi}$$

Other important information for the design engineer to remember is that the amount of bending is inversely proportional to the moment of inertia for the section being considered. The moment of inertia of the section varies as a fourth power of its relative size. All this means is that a small amount of metal added to a design, in the proper place, can increase greatly the stiffness of the design.

The dimensional tolerances specified by a designer can more easily be met if every step from raw material to final gaging is inflexible. The same can be assumed with regard to the attainment to a specified surface finish. A design engineer, when calculating loads on a bearing, usually assumes infinite rigidity and perfection of geometric form in his calculations. Yet, many of us are aware of instances where conditions far different from those assumed exist. If failure of a part develops, the design engineer, in an attempt to justify his calculations and ignoring the flexibility which exists in all elements of the design and manufacture thereof, frequently resorts to dimensional and finish tolerances that multiply costs at a fantastic rate.

Not too many years ago the refinement of surface finish was supposed to be the answer to all designers' problems. We now have evidence that low roughness values and narrow dimensional tolerances cannot substitute for intelligent design and manufacture. A manufacturing organization is in the best position to correct the designer's thinking. Some may think that it is easier to change designers, but that might make it worse.

The Designer's Responsibility

Put yourself in the designer's shoes for a time. Would you appreciate having the shop add several unknown factors to your design plus the ones you have ignored? Yet this is done day after day.

An engine designer has a perfect right to expect that when he specifies a certain *diameter*, he will see a form that is *round* in one view. The inspection department will report to him that it has measured this diameter and found it round. The inexperienced designer in combination with an inexperienced inspector can get into trouble.

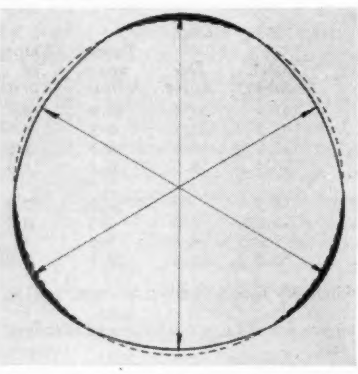

Fig. 1 Checking isodiametric crankpin with a micrometer or snap gage is unreliable

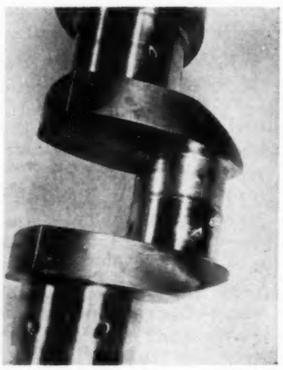

Fig. 3 Condition of crankshaft operated with bearings shown in Fig. 2

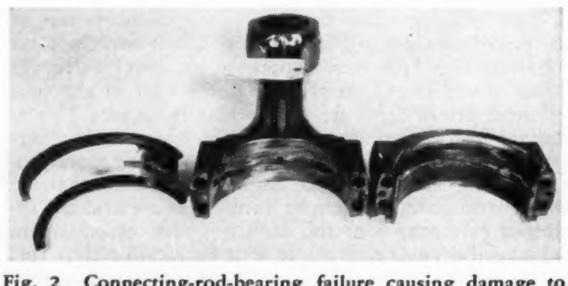

Fig. 2 Connecting-rod-bearing failure causing damage to crankshaft

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They should both ask, "How is roundness measured? With a micrometer? With a snap gage?" You cannot rely on either of these. Fig. 1 shows why they are unreliable.

If an isodiametric crankpin, like that shown in Fig. 1, with hills and valleys to sledge-hammer the bearing into submission, is operated in an engine, you can imagine the result.

Fig. 2 shows a connecting-rod bearing which has failed drastically and with continued operation has caused great damage to the crankshaft.

Fig. 3 shows the crankshaft operated with the bearings shown in Fig. 2. Note the low areas around the oil holes on the unfailed portion of the crank. Diametrically opposite these low areas, high points or hills were present which could not be measured with the ordinary micrometer. Photographs you have seen demonstrate to the designer that some unknown and very undesirable factors have been introduced into his design. Because of the great amount of publicity given to surface finish, with many men from many walks of life stating that if the surface were smooth enough it could operate in any kind of bearing, the designer was diverted from the true cause of the trouble. He first specified a very high polish or low roughness value. Instead of improving the bearing life, polishing of the crankshafts resulted in even greater incidence of trouble because polishing with wooden clamps fitted with emery cloth and held in a man's hand created a surface which departed from a true cylinder, but was isodiametric.

Checking a Cylindrical Surface

It soon became evident that the grinding and later finishing operations on all journals must be accomplished under the most rigid conditions possible. The inspection of surfaces for being cylindrical still presents a problem which has been partially solved as shown in Figs. 4 and 5.

Fig. 4 shows a blueing gage being prepared for inspection of a crankpin. The manufacture of the blueing gage requires careful designing, proper choice of materials, and suitable holding fixtures for refinishing. The blueing gage should cover at least one third of a diameter.

Fig. 5 shows a crankshaft with one crankpin and one main bearing which has been inspected with a blueing gage. You will note that the gage made contact with the journal and the crankpin over more than 80 per cent of the surface with no observable hills and valleys. Many diesel-engine manufacturers now are using crankshafts inspected by this method.

Gage Requirements

A plug gage is a really rigid and fairly well-designed inspection tool. However, unless extreme care in the manufacture of this gage is exercised, it can be subject to the same troubles that used to be common on crankshafts.

The thread gage should have good rigidity and accuracy unless we think of the thread as a triangular piece of metal, a foot or more long, which is expected to slide over another piece of triangular metal for its entire length. Viewed in this manner, the thread gage and the hole it is measuring are both nonrigid. In addition to their lack of stiffness, they are almost impossible to measure for surface finish.

Fig. 4 Preparing a blueing gage for crankpin inspection

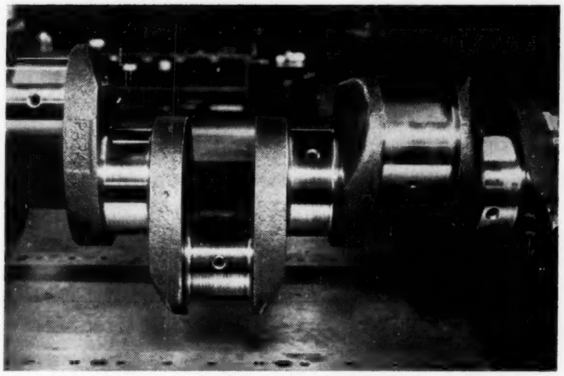


Fig. 5 Crankshaft after inspection with a blueing gage

Inside and outside calipers are frequently the only inspection tools that can reach certain surfaces which are too narrow and too well hidden for more rigid tools. Designs which have dimensional-tolerance specifications on surfaces that must be measured with tools such as calipers should be avoided.

The conventional height gage with indicator and other attachments is usually a big, shiny, important-looking inspection tool which has a vernier that makes a very good impression when read with the biggest magnifying glass in the department. It would be interesting to know why inexperienced inspectors or apprentices invariably use a height gage with an indicator for making measurements. The combination of these two pieces of equipment cannot be accurate if accuracy has any relationship to rigidity. Their dependency on a surface plate of doubtful flatness, together with the effect temperature has on the length of the vernier, leaves much to be desired.

Many designers and inspectors will accept as gospel truth readings taken with the foregoing tools. It is hoped that a healthy doubt can be created in their minds and some respect for the decimal point be engendered.

On the many thousands of measurements that must be made on a diesel engine during its manufacture, rigidity is frequently lacking. Inspection tools have sacrificed accuracy, which depends on rigidity, for lightweight and streamlined appearance.

One thousandth of an inch when first determined by

the micrometer was quite a conversation piece, but now we are faced with one thousandth of a thousandth of an inch or the microinch as a new conversation piece. The gaging and machine-tool industries have made marvelous strides, but the decimal point is still a long way ahead of them.

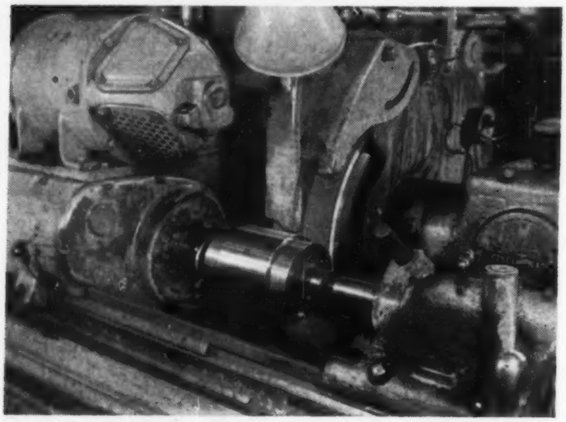


Fig. 6 Machine setup for grinding a thin-walled bushing

Rigidity in Machining Operations

On the machining side of the picture, only increased rigidity in tools, jigs, fixtures, and work supports will help to attain the designer's wishes at a reasonable cost.

Fig. 6 shows a thin-walled bushing and an arbor which supports it during the grinding operation. An observant design engineer can learn much by noting where and how the machinist supports the work in order to attain the specified dimension and finish. We have all seen designs of flimsy pieces which will later be contained in a rigid housing. Nevertheless, they must be manufactured so that their shape before assembly is held to very close limits.

Costly Finishes

Fig. 7 shows a connecting-rod bolt with a specified finish of 125 microinches all over, with the exception that the finish on the shank diameter has been deleted. Using 32 microinches as a base line, a finish of 16 microinches increases the price 22 per cent and 4 microinches increases the price 38 per cent. It is quite obvious that the manufacturing equipment, which attempts to produce such high-grade finishes, needs some improvement to reduce the cost.

Fig. 8 shows a simple wrist pin on which costs were determined for pins identical in all respects except for surface finish on the outside diameters. Again using a 32-microinch finish as a base line, 16 microinches increased the cost by 10 per cent; 4 microinches increased the cost 32 per cent. It is evident that the microinch is more expensive than the thousandth of an inch.

Fig. 9 shows a piston that looks pretty sick. This piston, when new, had a surface finish of 15 microinches. It was operated in a cylinder which had been finished to a maximum of 8 microinches.

Fig. 10 shows a piston of similar design and manufacture as Fig. 9, with the principal exception that the piston and liner finishes were in a region of 50 microinches. The choice is obvious.

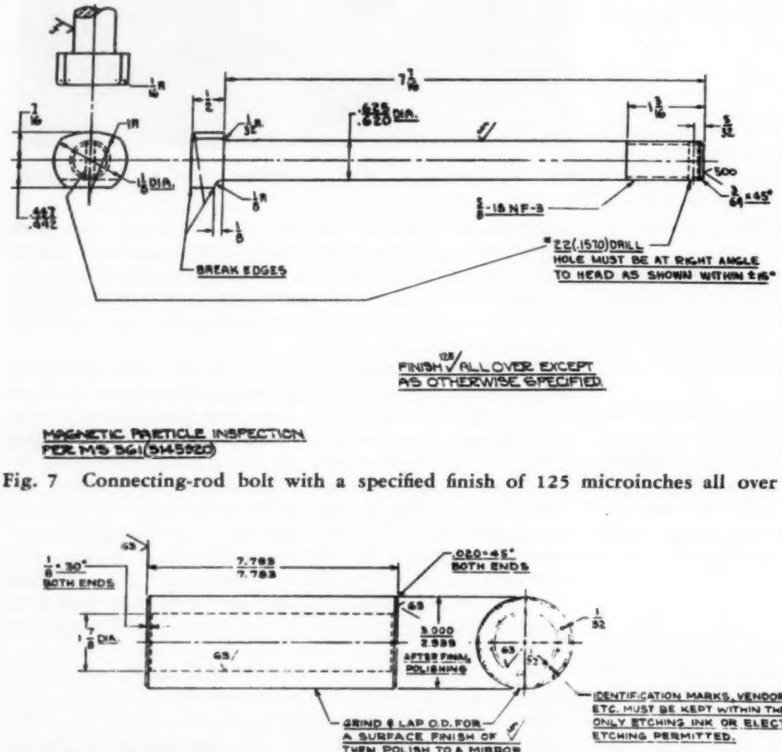


Fig. 7 Connecting-rod bolt with a specified finish of 125 microinches all over

How Much Finish Is Required

Each time a designer requires that a surface be finished, he should give careful thought as to whether or not it *needs* to be finished, how rough it can be, and how it will be manufactured.

As engineers, we must recognize that high polish is here to stay, but we do not need to specify shiny finishes on every surface. Fig. 11

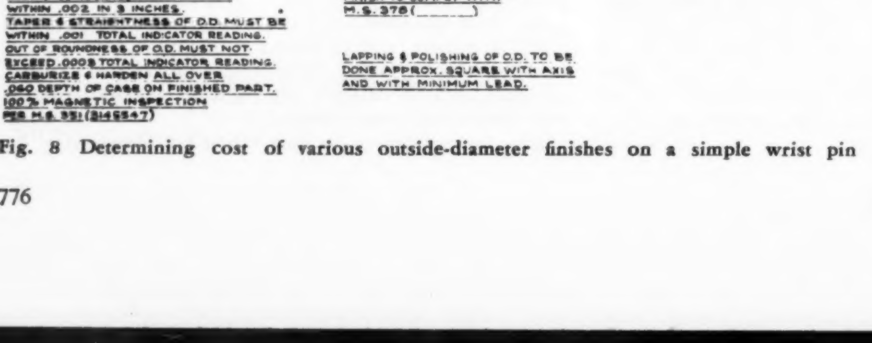


Fig. 8 Determining cost of various outside-diameter finishes on a simple wrist pin

Fig. 9 Result of badly matched piston and cylinder finishes

Fig. 10 Piston and cylinder liner with a 50-microinch finish

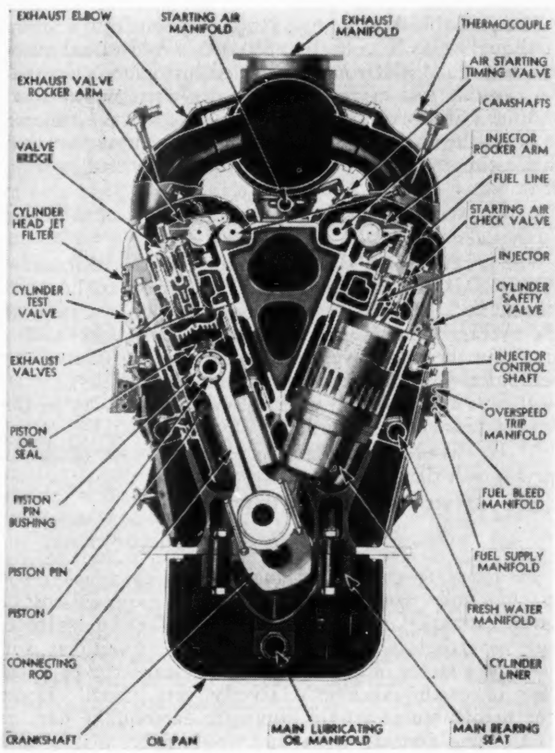


Fig. 11 Sectional view of a typical diesel-engine cylinder

shows a typical diesel-engine cylinder. Here is a rough count of the machined surfaces: 139 surfaces are finished on a milling machine; 153 are turned; 157 are ground; 253 holes are drilled and 31 reamed. Fifty-three of those holes are tapped. With the fuel-injection system, in excess of 1000 surfaces must be machined for each cylinder. This highlights and multiplies the importance of dimensional and surface-finish tolerances.

Temperature Effects on Gaging

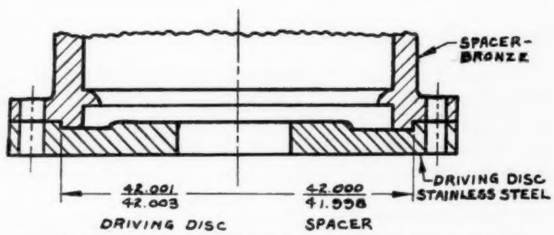
The effect of temperature on the gaging tools, as well as the parts being manufactured, can be quite appreciable for some materials. On an application involving a stainless-steel disk and a bronze spacer, pilot diameters were specified as given in Fig. 12.

Fig. 12 shows that 10 deg difference in temperature will change the size of the parts more than the designed dimensional tolerances. Here again, gages made of the same material as the finished parts have proved valuable. Master gages with hardened ends are used frequently to counteract the temperature effect.

Conclusions

1 The present methods of work support used in machining crankpins do not have the required rigidity for producing round diameters.

2 The tool-and-gage industry does not supply, on a catalog basis, tools of sufficient accuracy for measurements in thousandths of inches beyond 12 in.



TABULATION OF DIAS AT DIFFERENT TEMP.

TEMP F°	DIA.-DRIVING DISC.	DIA.-SPACER
60	41.997 / 41.999	41.996 / 41.994
70	42.001 / 42.003	42.000 / 41.998
80	42.005 / 42.007	42.004 / 42.002
90	42.009 / 42.011	42.008 / 42.006
100	42.014 / 42.016	42.013 / 42.011

Fig. 12 Pilot diameters on stainless-steel disk and bronze spacer

3 Temperature effects on sizes and shapes of stainless-steel and bronze parts are of such a magnitude that constant-temperature machining and measurement is a necessity.

4 Lack of stiffness often requires additional roughing and semifinishing operations, resulting in cost increase.

Evaluating Intangibles *for Executive Decision*

By A. L. Stanly

Director of Planning

Associated Missile Product Corporation, Pomona, Calif.

An executive's ability to make good decisions is one of the major contributions to his position. This is because the making of correct decisions is a difficult art which requires the balancing of a multitude of factors and the application of judgment. This latter quality is particularly necessary because many of the factors that must be balanced are of a noncommensurate intangible nature and cannot be evaluated readily in terms of numerical quantities.

It is because of this difficulty that the judgment exercised in making executive decisions is necessarily based in part on an intuitive evaluation. Thus intuition also plays a prominent part in executive decision making. This intuition can be described as the spontaneous integrated result of past experience, logical reasoning, and personal preference. Hence decisions which are based in part upon intuition are less secure, in general, than those which are based upon a simple balancing of numerical factors.

Concept of "Expected Cost"

The types of intangible factors which are vulnerable to the technique under discussion are those which can be more specifically described as "improbables." These are items which are large in magnitude but of infrequent occurrence. Evaluation of these improbables involves assessing the product of a large quantity and a very small probability. Hence they resemble the analogous mathematical quantity expressed as infinity times zero, which is an indeterminate quantity. They are, therefore, difficult to assess intuitively and often are considered as being intangible.

It is this type of intangible, i.e., the improbable, which is subject to analysis and ultimate numerical expression. The technique proposed as a means of evaluating these quantities is basically a simple one, and consists merely of calculating the "expected cost or value" of one cycle of a given type of event. This concept and its application may be clearer from consideration of a simplified but otherwise indicative problem as follows:

Consider the problem of a manufacturer who is anxious to expand his manufacturing facilities. While he prefers to build in California, he has been impressed by the earthquakes that have occurred there during the past year and is concerned about the possibility of losses from earthquake damage.

For the sake of this example we may assume that he finds the cost of insurance is, in his opinion, excessively high. Hence he is left to his own evaluation. If he approaches the problem intuitively, he will conclude that the possibility of an earthquake is an intangible factor and will make his decision in part on the basis of his existing emotional concern with regard to natural catastrophies. Alternately, he could attack the problem analytically somewhat as follows:

1 He would estimate the cost of an earthquake if it occurs:

The probable damage to a $100,000 plant from a severe earthquake may be as high as $50,000. Additional losses by loss of good will from disgruntled customers, unavailable capital, loss of prospective sales, etc., might total another $50,000. Thus the cost of the event is estimated to be on the order of $100,000. He notes, however, that this estimate might be in error by a factor of two up or down.

2 He would estimate the probability of a severe earthquake occurring:

The probability of a severe earthquake at the location of his 20,000-sq ft plant, over the period of financial strain, say, 10 years, can be estimated on the basis of the average area severely affected by earthquakes in this area over the past 50 years. Discussions with university geologists indicate that the probability of his 20,000-sq ft area lying within a severe earthquake area in the next 10 years is on the order of, say, 1 in 2000.

3 He would calculate the expected cost of earthquakes over the next 10 years.

The expected cost of an earthquake is

$$\$100{,}000 \times {}^{1}/_{2000} = \$50$$

In assessing the significance of his calculation our manufacturer would note that the $50 expected cost of severe earthquakes is only good to its order of magnitude, but, nevertheless, is highly significant. Even if it is in error by a factor of 10, its import is clear—the expected cost of earthquakes is relatively very small. Hence our manufacturer would eliminate earthquake damage as a serious consideration, and would make his decision on the basis of the remaining factors.

It may be noted from this example that the calculation of expected cost involved the multiplication of two crudely estimated quantities. Most noteworthy at this point is that even though the estimates were crude, the conclusion drawn from the resulting expected cost was definite and unequivocal.

Application to a Sample Complex Problem

We may now consider the usefulness of the expected-cost concept in reaching executive decisions for more

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highly complex managerial problems. Some of the most difficult problems of this nature lie in the complex field of newly developed weapons, since there is as yet no directly applicable experience.

A problem typical of the type that must be solved frequently in devising weapon systems for modern national defense is that of deciding whether to mount the explosive components of a guided missile into the missile at a military depot or at the field. Although the problem may appear to involve only a small procedural detail, its solution will affect the expenditure of millions of dollars for depot and field buildings, equipment, and the numbers and training of military personnel.

For reasons of national security, it is not possible to go into detail or to attempt to reach a valid conclusion for a specific missile. Hence the discussion will deal with the types of considerations and values of parameters which are generally applicable to the various types of surface-to-air missiles used for United States defense against enemy bombers.

We may postulate that field assembly of explosives means shipment to the field of five separate packages containing, respectively: (1) The missile, except for explosives; (2) the rocket motor; (3) the rocket-motor igniter; (4) the war head; (5) the fuse.

We further postulate that field assembly of explosives requires appreciable assembly effort, since portions of the missile must be disassembled to insert explosive components, and then must be reassembled and realigned.

Depot assembly, on the other hand, permits shipment of only one package to the field and only relatively little field assembly. However, it offers the disadvantages that the explosives first must be shipped to the depot, where they are then put into the missile, and must then be reshipped while being sent to the field. Thus depot assembly includes additional shipping costs and the additional hazard of shipping explosives one more time than otherwise would be required.

The problem involves consideration of multiple factors including logistics, missile reliability, safety of handling explosives, and the costs of manpower, equipment, building, etc., which must be on hand at the depot or the field. For the purposes of this paper, however, it will be sufficient to postulate that manpower, equipment, building, and shipping costs balance out. Thus we are faced here with the problem of evaluating the relative effect of three apparently noncommensurate, intangible quantities—missile reliability, logistics (with respect to supply effectiveness), and hazard of shipping explosives. The problem will be attacked by determining the differences in the expected cost of each of these three items for field assembly of explosives relative to depot assembly.

Calculations

Logistics. We already have postulated that the actual costs of shipment have been taken into account as part of the tangible costs. Hence we are concerned here primarily with the losses that would occur by virtue of missiles becoming useless (i.e., unavailable at the time when they are needed), because of lack of one or more necessary components through shipping mishaps. The vulnerability of such mishaps applies mainly to the field-assembly case since field assembly will require shipment of five individual packages, whereas depot assembly requires shipment to the field of only one package. In order to determine the increase in losses resulting from shipping five instead of one package from depot to the field, we can postulate that the mishaps occurring to the one major package of the five are equal to those occurring when the entire missile is in one package and concern ourselves only with the losses due to mishaps of the four minor packages containing explosives.

Calculation of the expected cost of missiles becoming useless because of shipping mishaps is as follows:

(*a*) *Cost of a useless missile*. The missile cost that is involved in this case is the factory cost of building the missile, plus the costs of packaging, shipping, and intermediate storage. For a typical surface-to-air missile such as that under consideration here, this cost can be postulated at $25,000.

(*b*) *Number of vulnerable missiles*. The number of missiles which are vulnerable to loss should include only those missiles which must be supplied under wartime conditions, and which become useless if missing components are not resupplied within the time that the missiles are needed. Arbitrarily we may postulate, for the sake of the example at hand, that 12,500 missiles, approximately half of the missiles which will be used during the defensive air war, are already present at the bases which will use them. The remaining 12,500 are considered to be shipped during wartime from the depot to whichever base needs them, and hence are vulnerable to waste from supply mishaps.

(*c*) *Proportion of useless missiles*. The proportion of missiles that become unavailable because of lack of one of the four added packages when needed is strongly dependent upon the duration of the air war. If the air war is brief it can be expected that a not inconsiderable portion of items will be misplaced, damaged, or simply lost in shipment at the time they are needed. If the air war is prolonged, there will be time to correct most of the initial rush-shipment errors and to develop more careful procedures. Hence it is estimated that the proportion of useless missiles because of added shipping mishaps will range between 1 and 10 per cent. A mid-figure, therefore, of about 5 per cent should minimize errors of estimate for the purposes of this calculation.

(*d*) *Calculation of expected cost*. The expected cost, therefore, owing to the added losses attributable to shipping five packages to the field, instead of one, may be calculated as follows

$$\text{Expected cost} = \$25{,}000 \times 12{,}000 \times 0.05 = \$15{,}000{,}000$$

Admittedly, this figure is extremely rough; however, one conclusion is already clear—the expected cost of shipping losses is at least a few million dollars and may be many millions of dollars. It is, therefore, a substantial factor.

Some added definition may be gained here by considering the possible range of costs in view of the uncertainties of the available data. The probable minimum cost is determined from the product of all minimum estimates; the probable maximum cost, from all maximum estimates. This range can be shown to be $3,000,000 to $30,000,000.

Reliability. Calculation of the expected cost of the reduced reliability from field assembly, instead of depot assembly, requires estimates of three items, as follows:

(*a*) *Cost of an unreliable missile*. The method of evaluating this item deserves some elaboration because of the

diverse viewpoints surrounding it. There appear to be at least three bases upon which the cost of an unreliable, i.e., wasted, missile can be evaluated:

1 Value of what the missile accomplishes when it works.

2 Cost of the effort that was wasted by virtue of the missile not working properly.

3 Cost of replacing the unreliable missile and its corresponding auxiliary activities, so that the battery has the same effectiveness that it would have if the missile had worked properly.

The first basis seems an inadequate one for making calculations because it varies with each situation.

The second method of calculating costs—cost of wasted effort—also seems inadequate because it does not take into account the fact that the battery operates with reduced effectiveness when some missiles do not function.

The most reasonable basis of assessing cost in this case, therefore, appears to be the cost of restoring the battery effectiveness which would be lost by virtue of missiles failing in flight. This assumes that a given battery maintains its effectiveness in the case of reduced missile reliability by provisioning enough additional missiles, personnel, support equipment, maintenance, and so on, to make up for the missiles which do not work. This assumption is only reasonably valid if the make-up increment is a small proportion of the total, and thereby requires only negligible increase in the complexity of the operation. This is a reasonable postulate.

The cost of a missile delivered to the field has already been postulated as $25,000. In addition, it appears appropriate to charge unreliable missiles with any additional equipment or personnel costs that would be required by virtue of the additional activity which would be required to keep the battery effectiveness at the same level as it would be without the decrease in reliability.

An order of magnitude of a typical case can be derived from examining what happens if, say, an additional launcher is required per battery for the surface-to-air missile under consideration. It can be postulated that the launcher and associated electronic gear costs $100,000, requires six men per shift, with three shifts per 24-hr day, and that each man costs the nation $6000 per year plus $8000 training and preparation costs. If this launcher is maintained with appropriate stand-by manpower for, say, five years, then the total cost for the additional launcher per battery is on the order of $600,000. This launcher would be required to handle only a very few per cent of the battery missiles, resulting in, let us say, on the order of 20 missiles. It can be shown readily that for an additional launcher to handle "replacement" missiles, the cost of the added handling equipment and personnel would be $40,000 per missile plus the cost of the missile. Thus, for the purposes of this problem, we can reasonably postulate replacement costs per unreliable missile as being on the order of double its factory and handling cost, or $50,000 per missile.

(*b*) *Estimated total number of missiles to be fired.* This figure has been estimated already in a previous section as 25,000 missiles.

(*c*) *Estimated proportion of missiles failing in flight.* Here we are concerned not with the absolute unreliability of the missile but with the change in reliability which is attributable to assembling explosives into the missiles at the field instead of at the depot.

This assembly work sometimes will be done under emergency conditions when enemy aircraft are already overhead. Sometimes the work will be hurried, inspection may be inferior or nil, and working conditions may be poor. Hence it seems probable that a small proportion of missiles will suffer in reliability because of lower-than-depot workmanship.

The added proportion of missiles that fail from this situation cannot be determined precisely at the present time, since there is no experience with assembling this type of missile under field conditions. About the best that can be said is that the proportion of missiles that fail because of field, instead of depot, assembly of explosives will be small—greater than 0 per cent and probably less than 5 per cent, with an average estimate of, say, 2.5 per cent.

(*d*) *Calculation of expected cost.* From the preceding discussion we may calculate the expected cost of loss of reliability due to field assembly as follows:

$$\text{Expected cost} = \$50{,}000 \times 25{,}000 \times 0.025 = \$31{,}000{,}000$$

The estimated range of cost is $7,000,000 minimum to $93,000,000 maximum.

Explosive Hazard. We have postulated earlier that field assembly of the missile involves less hazard than depot assembly, mainly because it saves one transshipment of the explosives. The cost of explosive hazard is therefore estimated by the expected cost of the increased hazard due to an extra shipment of explosives.

(*a*) *Cost of the explosion.* The costs of an explosion are calculable as the losses of property and the losses of human life.

The loss of property that might be involved in an explosion of a missile-carrying freight train would include the costs of the surrounding property destroyed; the missiles which are destroyed; the freight train or portion thereof which might be destroyed.

It is easy, of course, to visualize an explosion of a few

Applying Expected-Cost Concept

The expected-cost technique appears to be applicable to many types of purely industrial problems, such as the following:

1 Design of a shipping container. Involved here is an optimum balance between the probability and magnitude of damage of the item protected by the container, and the relative costs of various shipping containers and methods of transport.

2 Design of a vehicle (train, truck, airplane) and handling procedures. Involved here is a balance between the cost of the damage to the merchandise carried and the costs of the improved vehicle design, refined handling practices, and time.

3 Location of repair facilities. This problem might involve the probable frequency of breakdowns and their probable locations and costs, including out-of-pocket expenses, loss of good will or prestige, disruption, and so on.

Table 1 Comparison of Field Assembly and Factory Assembly of Guided Missiles

Factor	Differential costs: Field assembly — Expected cost	Field assembly — Est. range	Depot assembly — Expected cost	Depot assembly — Est. range
Shipping mishaps	$15,000,000	$3,000,000 to 30,000,000		
Missile reliability	25,000,000	7,000,000 to 93,000,000		
Explosive hazard			$10,000	$100 to $100,000
Total	$40,000,000	$10,000,000 to $123,000,000	$10,000	$100 to $100,000

thousand pounds of explosive which will cause many millions of dollars of damage—say, if it occurs when the train is passing over a city bridge. However, the explosives train would be at such critical location only a very small proportion of its time of existence so that a multimillion dollar explosion would be the result of an improbable explosion occurring at an improbable location, or a doubly improbable event. For the purposes of estimating the average cost of an explosion, it is of only minor significance.

The cost of the missiles destroyed in an explosion of a freight train carrying 100 missiles can be estimated from previous calculations at $2,500,000.

The cost of the freight train, excluding the engine which should not be substantially damaged as it will be separated from the explosives-carrying cars, should be on the order of $1,000,000 at most.

Thus the average property loss due to explosion of a guided-missile freight train is conservatively estimated at $4,000,000.

In the case of loss of human life, emotionally speaking, the value is incalculable. Nevertheless, it is possible to put a figure on the money identified with accidental loss of life by evaluating how much money is available to prevent loss of life. On this basis it appears that the amount of money identified with a human life has a very finite value.

For the purposes of this paper it appears reasonable to equate the economic (not emotional) value of a human life at that amount of money which can be afforded to prevent its accidental loss in our society. This amount of money varies in a variety of circumstances but can be assessed as normally being less than $100,000 and more than $10,000. To be conservative, we may postulate an allowable expenditure of $50,000 per life saved.

The average number of lives which might be lost in the event of the explosion of a freight train carrying guided missiles containing in all a few thousand pounds of high explosives may be as low as one and as high as two dozen. An average figure of 12 lives per explosion therefore seems reasonable and yields $600,000 per explosion as a measure of the economic value of loss of life.

Thus the total expected cost of an explosion is estimated to be on the order of $5,000,000.

(*b*) *Number of shipments*. For the purposes of this study it is postulated that missiles will be shipped in average loads of 120 missiles per freight train. Thus at a total of 25,000 missiles, approximately 200 freight-train shipments will be made.

(*c*) *The probability of an explosion*. This probability depends upon the care which is taken with explosive shipments and the inherent stability of the explosives being shipped. It is felt that this probability should be very low since even with the type of explosives that have been used during the past three wars, only one freight car of explosives has been known to detonate in the past 50 years.

The probability of a freight-car explosion for the case at hand is, therefore, very low and is crudely and conservatively estimated to be on the order of not more than one in 100,000.

(*d*) *Expected cost of an explosion*. The expected cost of an explosion is, therefore, calculated as follows:

$$\text{Expected cost} = \$5{,}000{,}000 \times 200 \times 1/100{,}000 = \$10{,}000$$

This expected cost is only roughly approximate but is negligible in magnitude for the situation at hand. This is clear when it is recognized that it could be increased by a factor of even 100 before becoming significant relative to the other items under consideration.

Conclusions for Sample Problem. The analysis has shown that the expected cost of decreased reliability and reduced supply effectiveness for field assembly of explosives should be balanced against the expected cost of increased hazards of explosives transshipping for factory assembly of explosives. Table 1 shows the balance.

The table shows that for the conditions of the sample problem there is a saving in expected cost of about $40,000,000 for depot assembly of explosives. Despite the uncertainty of the basic data, a substantial saving seems extremely probable since comparison of even the minimum estimates of field-assembly costs with the maximum estimate of depot-assembly costs shows an advantage for depot assembly of nearly $10,000,000. A decision to plan for depot assembly is strongly indicated.

Some incidental results of the study of the sample problem are the indications that a small decrease in the reliability of a weapon such as a guided missile can be highly expensive. Supply mishaps similarly can involve substantial costs. Analysis also indicates that the expected cost of explosive hazards is very low for the case at hand.

Conclusion

Because probabilities are involved, and because it is possible to make gross errors of estimate with regard to situations which do not yet exist, it should be recognized that the technique proposed is subject to error. However, the possibility of error usually can be discovered by checking to see if there is an overlap in the estimated range of costs for the factors being balanced. Moreover, the proposed technique of evaluating intangibles should always be at least a better guide than simple intuition since it requires a breakdown and examination of the contributing factors of each consideration and thereby localizes and minimizes the possibility of error.

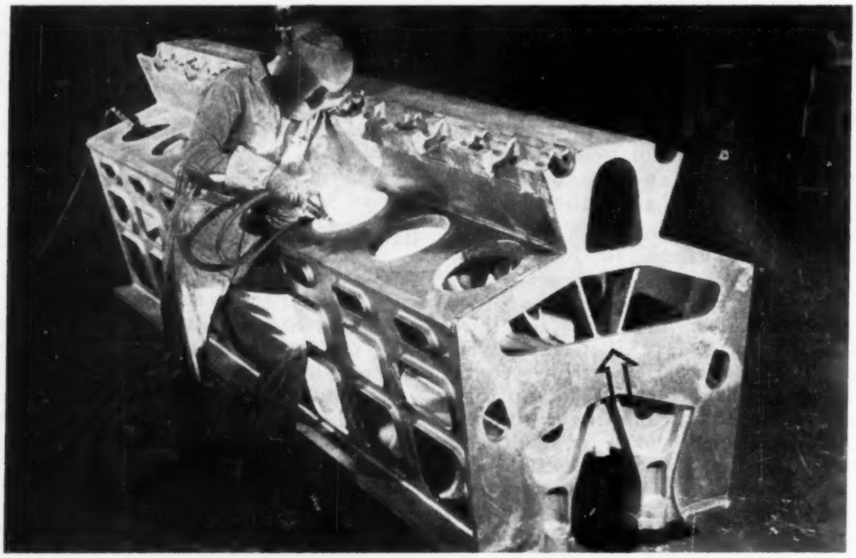

Fig. 1 V-type diesel-engine frame of the type fabricated from stainless steel for use in nonmagnetic mine-sweeper program

Welding Comes of Age . . .

. . . New Applications

By John L. Lang

Welding Engineer, Lukenweld Division, Lukens Steel Company, Coatesville, Pa.

Less than 40 years ago welding was a process used principally in the blacksmith shop. Today without exception every metal-fabricating industry uses welding. Yet it is difficult to realize that this universal application of welding has occurred in only the past 10 years. Today when a new metal is discovered or a new alloy developed, one of the first questions concerns its weldability. The American Welding Society's Master Chart of Welding lists some 37 separate processes. However, the following discussion will be limited to only a few of these processes which are particularly suitable for production work.

Manual Shielded Metal-Arc Welding

Manual shielded metal-arc welding means an arc-welding process wherein coalescence is produced by heating with an electric arc between a covered metal electrode and the work; shielding is obtained from decomposition of the electrode covering. Pressure is not used and filler metal is obtained from the electrode.

Contributed by the Production Engineering Division and presented at the Diamond Jubilee Spring Meeting, Baltimore, Md., April 17–22, 1955, of The American Society of Mechanical Engineers. Based on the following two papers: "New Applications for Welding," by J. L. Lang, and "Production-Welding Principles," by M. D. Thomas.

The welded-steel diesel-engine frame is not very new. However, the welded stainless-steel diesel-engine frame is a new application. The stainless is used for its nonmagnetic properties. Eight-cylinder upright, 8 and 12-cylinder V-type, engine frames have been welded with special Type 308, manual shielded metal-arc electrodes. The parts are fabricated of Type 304-18-8 stainless steel from rolled plate, cut, and formed. The bearing housings are drop forgings of the same material.

Fig. 1 shows a V-type diesel-engine frame. Several hundred 8 and 12-cylinder stainless-steel frames have been fabricated for the nonmagnetic mine sweeper program. The welded engine represents a reduction of 67.39 per cent in cubic feet occupied per bhp and a reduction of 58.40 per cent in weight per bhp as compared to the old cast-iron diesel.

Two columns were fabricated by manual welding for a 3,000,000-lb extrusion stretcher recently placed in service at the Lafayette, Ind., works of the Aluminum Company of America. Each column is 130 feet long and weighs approximately 1 ton per ft. One was built straight and the other with sufficient camber to be straight when supported at each end. There were 36 holes in each of the 4-in-thick side members. The locations of the holes were critical and had to be cut after

complete fabrication. A procedure was worked out to keep distortion at a minimum. The complete machine is 180 ft long over-all and is capable of stretching a 120-ft length of 75S extruded shape with a cross-sectional area as large as 60 sq in. The maximum width that the stretcher can accommodate is 37 in.

Another application of shielded metal-arc welding is the fabrication of large power-plant weldments. The low-pressure turbine cases are fabricated entirely of rolled plate, gas-cut, machined, formed, and welded. Large stator frames are fabricated in the same manner from plate stock, and welded into a homogeneous mass.

Fig. 2 shows the completed powerhouse installation consisting of a high-pressure turbine usually fabricated of alloy castings, and frequently welded; the low-pressure turbine; and the generator. This unit has an 80,000-kw capacity, which is sufficient to supply the power needs of a good-sized city.

Submerged-Arc Welding

Submerged-arc welding means an arc-welding process wherein coalescence is produced by heating with an electric arc or arcs between a bare metal electrode or electrodes and the work. The welding is shielded by a blanket of granular fusible material on the work. Pressure is not used and filler metal is obtained from the electrode and sometimes from a supplementary welding rod.

Two very large presses are now being constructed. Most of the welding on the main structures was accomplished with the submerged arc-welding process. Large beams of web and flanges had 12-in-thick butt joints of double U-design welded with the multipass submerged-arc process. The crossbeams for both the 50,000 and 35,000-ton presses had $8^1/_2$-in-thick butt joints in 70,000-psi tensile steel which required approximately 100 beads or passes of weld. More than 1000 lb of weld wire were used in each joint. The structures were preheated to 350 F and maintained at, or above, that temperature during the welding operation. These presses are to be used for the fabrication of aircraft components.

A submerged-arc process is being applied to high production of automobile-chassis frames in a large eastern plant. The welding is done in the three o'clock position on 0.093-in-gage low-carbon material. The type of joint is a lap with the outside edge up. The machine is fully automatic having six welding heads which track in three planes, with a travel speed of 150 ipm. Two such units produce 1400 frames per shift or 2800 per day working two 8-hr shifts. The floor-to-floor time per frame is roughly 30 sec. The units do the work formerly requiring 40 manual arc welders.

Inert-Gas, Shielded-Metal-Arc, Nonconsumable-Electrode Process

This process utilizes an inert gas, helium or argon, and a tungsten electrode. The filler metal is fed into the arc or the joint is designed in such a manner that the edges are melted down and no filler metal is required. A machine automatically welds stainless-steel hermetically sealed aircraft contactor cases by this process. This machine traverses over irregular circumferential contours automatically holding the arc length constant and a linear welding speed during the full 360-deg rotation, then tapering the current to zero to avoid craters. A nesting fixture mounted in a retracting breech block facilitates rapid loading and unloading of work parts. Welding-electrode position has accurate stepless adjustment which also can be accomplished during welding. Completely automatic machine sequence has a stepless variable-speed drive and automatic shutoff.

Inert-Gas, Shielded-Metal-Arc, Consumable-Electrode Process

As the name implies, the electrode is fed into the arc mechanically and is consumed in the weld as filler metal.

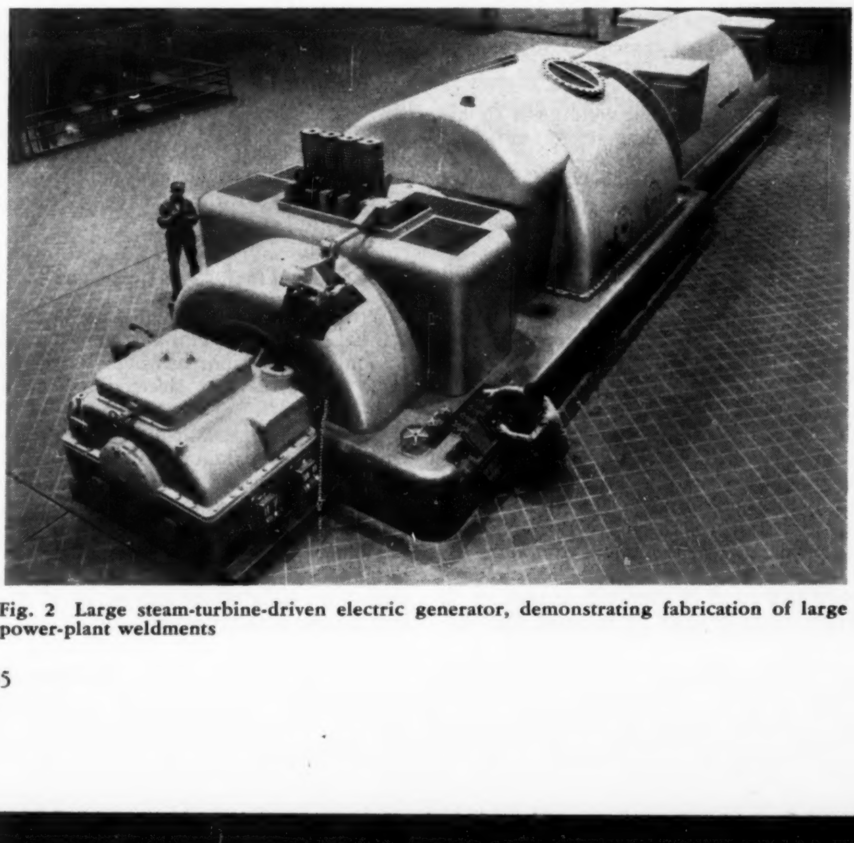

Fig. 2 Large steam-turbine-driven electric generator, demonstrating fabrication of large power-plant weldments

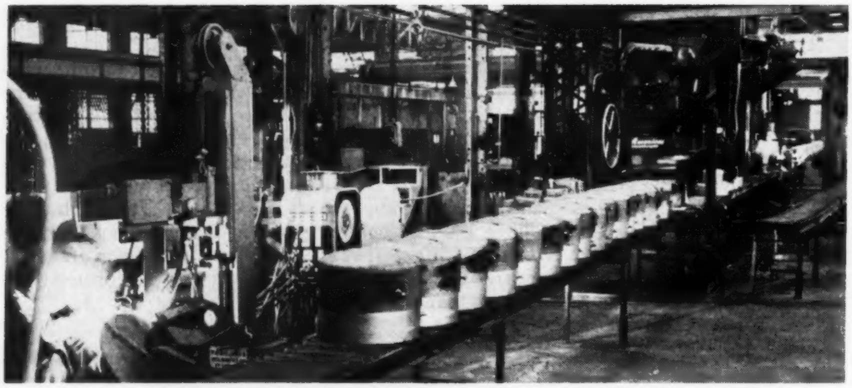

Fig. 3 Production-line setup for fabrication of refrigeration compressor cases. Sixty units are assembled, welded, and tested in an 8-hr shift.

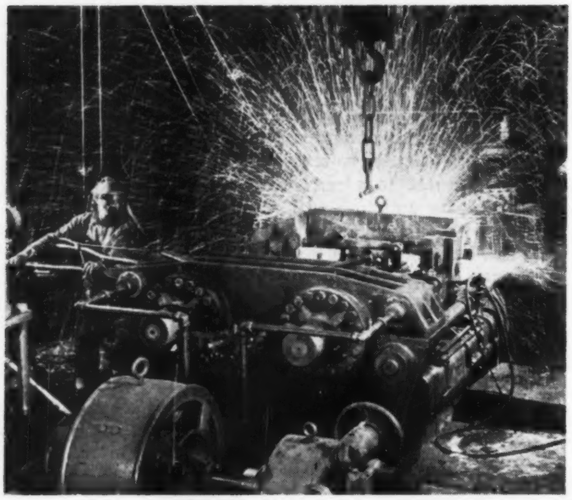

Fig. 4 Large flash welder having a capacity of 36 sq in. of joint in a single weld

This process has greatly facilitated the welding of aluminum, copper and its alloys, stainless steel, steel, and titanium.

One of the earlier applications of this process to mild steel was the fabrication of refrigeration compressor cases of 5-hp size. Fig. 3 shows a production-line setup for fabrication of the cases. Sixty units were assembled, welded, and tested during an 8-hr shift. Two inert-gas shielded-metal-arc units were used in welding the 110 in. in the three main joints of this fabrication.

Spot, Seam, and Projection Welding

Spot, seam, and projection welding is a group of welding processes wherein coalescence is produced by the heat obtained from resistance of the work to the flow of electric current in a circuit of which the work is a part, and by the application of pressure through electrodes. In spot welding, the size and shape of the individually formed welds are limited primarily by the size and contour of the electrodes. In seam welding, the electrodes are circular. The resulting weld is a series of overlapping spot welds made progressively along a joint by rotating the electrodes. In projection welding, the resulting welds are localized at predetermined points by the design of the parts to be welded. The localization is usually accomplished by projections, embossments, and intersections.

In 1932 the refrigerator consisted of a cabinet frame of wood with metal panels screwed in place. Welding was still untried as a production tool. In 1933 the refrigerator shell and liner first used some welding, but on a limited scale. However, today the manufacturers of refrigerators utilize resistance welding extensively in every major assembly.

The story of the electric range is much the same. Welding was confined to simple spot welding on the frame, top, oven, and drawer. All welding was done on standard spot and gun welders using simple fixtures and production was very slow.

The 1954 range has a new look. Beneath the splendor of gleaming porcelain and chrome are 235 individual pieces that are joined together by 1150 spot and projection welds. The amazing part of it is that these 1150 welds require just under 1 hr of productive labor as determined from time studies. This time includes handling of all parts into and out of the welders as well.

Flash Welding

Flash welding is a resistance-welding process wherein coalescence is produced simultaneously over the entire area of abutting surfaces, by the heat obtained from resistance to the flow of electric current between the two surfaces, and by the application of pressure after heating is substantially completed. Flashing and upsetting are accomplished by expulsion of metal from the joint.

A Midwest company fabricates 40-ft sections of pipe by flash-welding the entire length in one operation which requires about 35 sec. A large flash welder is now being used to fabricate crankshafts. Flash welding is used extensively in automobile-body fabrication. Fig. 4 shows a flash welder with a capacity of 36 sq in. of joint in a single weld.

New Shielded Metal-Arc Electrodes

With the atomic age comes the latest developments in manual shielded metal-arc welding electrodes. About the only connection, however, is through some of the trade names of these electrodes, such as "Atom-Arc" and "Jet Weld."

These are the new iron-powder-type electodes about which a great deal more will be heard in the near future.

As American industry stands on the brink of a new production revolution, that of automation, welding will play a key role. Only welding can join metal parts in the continuous and high-speed processes which automation demands. Equipment is already in use in the automotive industry which can make 30,000 welds an hour and the end is not in sight.

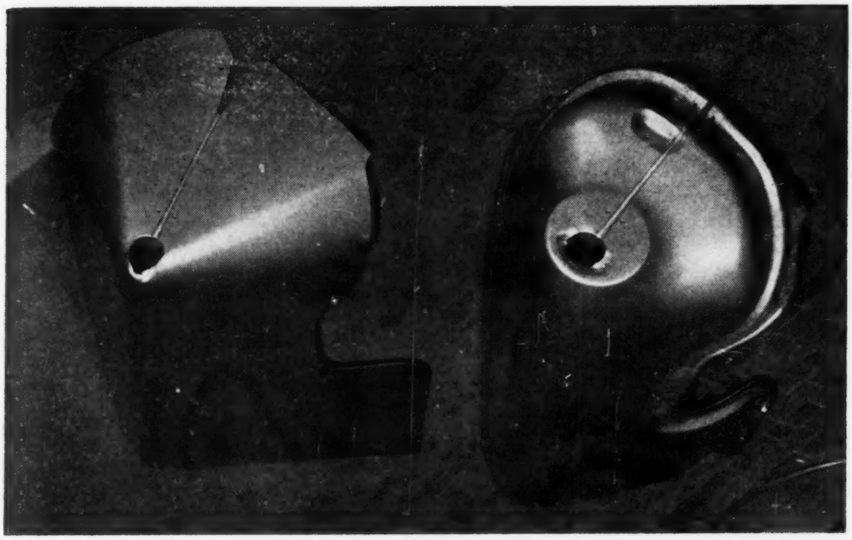

Fig. 1 Automobile fenders planned and designed co-operatively as weldments accomplished great savings in time and materials, as compared to deep-drawing operations

. . . Principles of Production Welding

By Morris D. Thomas

Head of Welding Engineering
General Motors Institute, Flint, Mich.

Key to Production

1 Co-operatively plan and design product as a weldment.

2 Design for material, process, equipment, and welding technique to be used.

3 Provide equipment and tooling with productive capacity and service life required.

4 Install equipment properly with utilities of capacity needed for job.

5 Supply specified materials for welding operation.

6 Set up and adjust welding equipment to produce welds within specified limits on a production basis.

7 Control and maintain welding operation so that weldments of specified quality are made consistently.

PRODUCTION-WELDING principles are guides whose proper application makes possible the manufacture on schedule of functional well-styled weldments of consistently good quality and whose sale and use result in the lowest costs and highest profits to all.

Co-Operative Planning and Designing

This first principle is applied as soon as the product-engineering group comes up with a functional design or a working model that meets a recognized need for a new product or that fulfills a demand for a change or improvement in a current one. Experience has shown that the thinking of a group of people is much better than the thinking of one individual in the development of a product for manufacture. The group of people brought together must pool the kinds of experience needed to produce a sound production design of the product. In addition to product engineering and design experience, the kinds of experience needed for this task may include:

(*a*) Product performance, sales and service experience.
(*b*) Materials, metalworking, and metallurgical experience.
(*c*) Processing and process experience.
(*d*) Process control and inspection experience.
(*e*) Tooling and equipment experience.
(*f*) Plant-engineering (utilities, installation, layout, and maintenance) experience.
(*g*) Manufacturing and production experience.

Contributed by the Production Engineering Division, and presented at the Diamond Jubilee Spring Meeting, Baltimore, Md., April 17–22, 1955, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

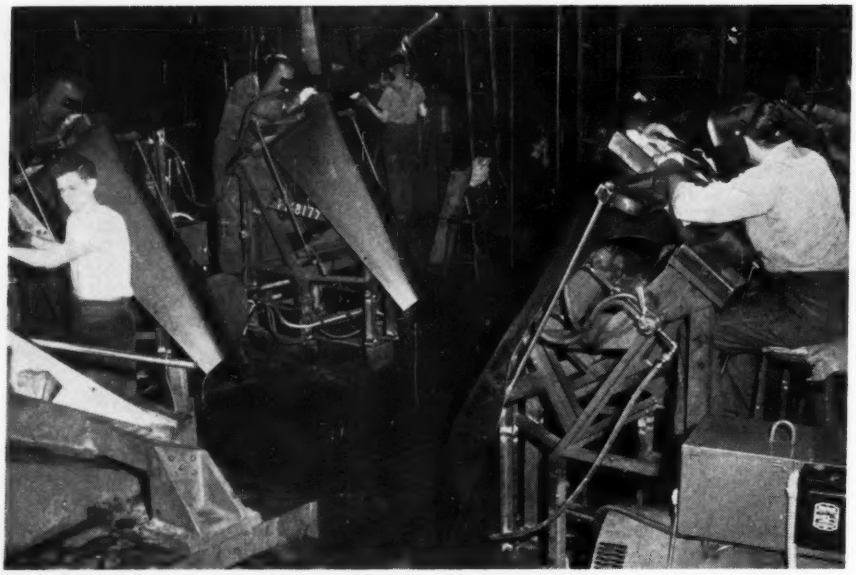

Fig. 2 Manpower and equipment required when welded fabrication of fenders as shown in Fig. 1 was first introduced

(*b*) Production control, standards, and training experience.

The automobile industry widely uses this first principle in production design. For example, production problems were mitigated and manufacturing costs were reduced when automobile fenders were planned and designed co-operatively as weldments as shown in Fig. 1. The design of this product as a weldment eliminated deeper drawing operations, annealing operations between draws, saved tooling, and virtually eliminated scrap losses in the drawing operation.

When the co-operative design group agrees that the product is to be made as a weldment, apply the second production-welding principle before "freezing" the final product design.

Designing as a Weldment

The reaction of the materials to be joined to the application of heat and/or force, addition of filler metal, shielding and fluxing, and the degree to which these elements must be controlled determines what operational characteristics are required in a welding process and the kind of welding equipment that must be used. The weldabilities of some materials are such that they can be welded readily by a number of processes. In that case the final selection of process is based on other factors.

When more than one process is acceptable from a materials viewpoint other factors determine which one is selected for use.

Once a process compatible with the material has been selected tentatively, consideration must be given to the details of weld-joint design best suited for the machine, tooling, and welding technique to be used.

In one set of published standards of design data for groove-weld joints, over 125 joints for fusion-welding of steel are listed. These standards do not include groove joints for deep-penetration techniques which are characterized by smaller root openings, wider lands, and less plate preparation.

The best guides to follow in selection of groove-joint designs are as follows:

1 Minimize the number of weld joints and the length by simplifying design to reduce number of parts. Eliminate welds by bending or forming operations.

2 Select joints that minimize the amount of plate preparation before welding.

3 Use the minimum amount of weld metal possible. Capitalize where possible on deep-penetration techniques. Weld metal is the most expensive metal in a weldment and the overuse of it will increase warpage and distortion problems as well as manufacturing costs.

4 Provide joints that make possible the highest heat input and the largest-size welding rod or welding electrode that consistently will provide the quality of weld needed.

5 With slag-producing processes, design for the minimum number of weld passes.

6 Design weld joints whose fitup, root gaps, and lands can be maintained in production and assembly operations. Poor fitup and variation in gaps destroy the advantages of efficient joint design and prevent effective production flow.

7 Correlate joint design with production flow and assembly procedures. Design joints which minimize handling, are readily accessible when placed in jigs and fixtures, and can be positioned easily for down-hand welding.

8 Select a joint readily accessible to, and in the best welding position for the process, type of machine, and welding technique to be used.

When the weldment, the weld joint, and the welding have been designed, apply the third production-welding principle.

Equipment and Tooling

The properties of the materials to be welded determine whether the production-welding equipment and tooling

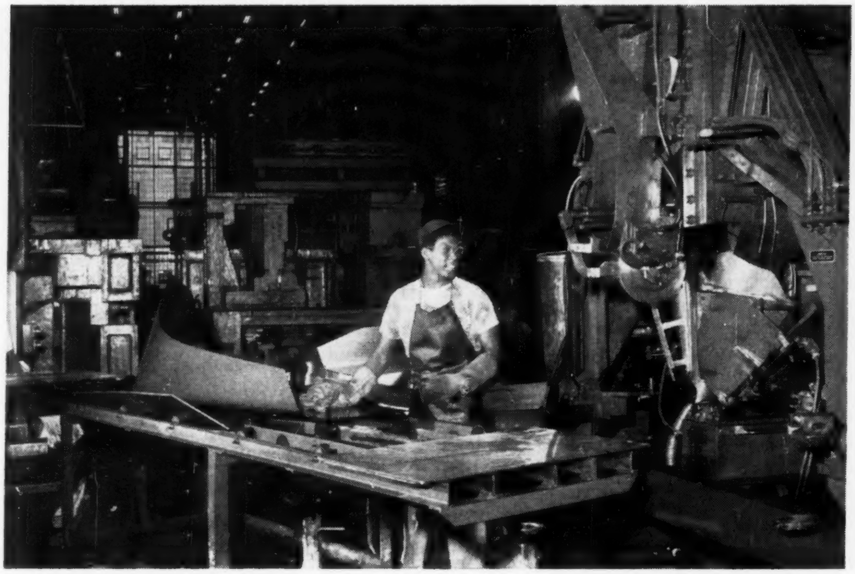

Fig. 3 One operator and equipment are now used to fabricate fender weldments on a production basis

will be able to supply heat, force, filler metal, shielding or fluxing for the joining task.

The physical size and shape of the joint, the maximum period of time available to make the joint, and whether the weld is to be made simultaneously or progressively determine the productive capacity of the machine.

The joinability of the material, the service performance required of the weldment, and the critical factors in the processing of the product determine the degree of precision of the parts and the accuracy of the control needed over the operating characteristics of the process by the machine.

Production rates, number of shifts worked in one day, effect of machine breakdown on plant-production costs and consistency in machine operations required determine the durability life or maintenance provisions that must be provided in the welding machine.

The extent to which funds must be invested in equipment and tooling increases with higher production rates, with the total pounds of filler metal to be placed in the joints, the total number of welds, and the total period of time over which the welds are to be made.

Joint preparation, weld cleaning, weld treatment, direct labor, filler metal, shielding, fluxing, and equipment-maintenance costs all determine how much money can be spent on equipment and tooling.

Absence of the following indicates that equipment and tooling with the productive capacity and service life required are being used on the job:

1 Excessive part replacement and high maintenance costs.
2 Excessive downtime and production delay.
3 Variations in weld quality.
4 Large number of weld rejects, reruns, scrap weldments, and repairs.
5 Accidents and safety hazards.
6 High product service costs resulting from weld failures in the field.
7 High or variable weld-material costs.
8 High production and material-handling labor to equipment-cost ratio.
9 High skilled production labor-training costs.
10 Too long machine pace or cycle-time requirements to meet production needs. Output ratio low when compared to other machines available.

Progressive manufacturing organizations constantly study current production and projected welding operations to establish whether or not the organization is paying out the cost of more productive equipment and tooling while being deprived of the benefits of its use.

Figs. 2 and 3 show how constant study of the production-welding equipment used to fabricate the fender weldment shown in Fig. 1 has increased productive capacity and extended service life. Fig. 2 shows the equipment and manpower used when the operation was first introduced. Fig. 3 shows the equipment used to produce the fender weldment currently.

Capacity for the Job

When circuit breakers pop, fuses blow, lights flicker, air or hydraulic-actuated devices become sluggish or erratic in action, resistance-welding electrodes mushroom excessively, ignitron tubes become gassy, cables and transformers overheat and burn out, overload controls refuse to allow the equipment to operate, and welds are inconsistent in quality, it is time to find out if the utilities are adequate for the job.

Simple checks can be made with equipment available in maintenance departments or available at reasonable cost to determine if a machine is installed properly or is operating beyond the capacity of the utilities system. Proper planning of air, electrical, hydraulic, and cooling systems is a necessity if weldments are to be produced on a production basis. Service engineers from the utilities and equipment manufacturers when called upon will assist in planning new installations or correcting faults in old ones.

Meeting Parts Specifications

Many production-welding problems have their origin in the preparation of parts for the welding operation. It is the responsibility of the design and process engineers to see that the parts to be welded are designed with proper tolerances and processed in such a way that weldments to specifications can be made.

This means that the stock must be "clean." Provisions must be made in processing to remove harmful foreign substances, rust, oxides, or other surface films on the material that interfere with the joining operation.

The roughness of the surface must be controlled in those cases where it affects the quality of the weld. Control also must be established over the dimensions of the parts going into a welding operation. Special attention should be given to weld-joint preparation, flange width, size, shape, and location of projections (in projection welding) and "spring back" of material.

No substitution of materials as to metallurgical characteristics, method of production, degree of freedom from harmful discontinuities or impurities should be made before the effect of this change on the welding operation has been established. There are cases where it is necessary for such items as metal cleaners, heat-treating materials, rust preventives, and paint to be selected on the basis of their effect on the welding operation. Failure to notify those responsible for welding of changes in these materials in some cases has resulted in the creation of welding problems and expensive production delays.

Any advantage gained in an attempt to use a welding machine as a forming press to bring stampings to their proper shape or to add additional weld metal to take care of variations in dimensions of the part are more than offset by loss in production efficiency and weld rejects.

Setting Up and Adjusting Equipment

Welding equipment must be set up and adjusted to produce welds within specified limits on a production basis. There should be provided proved welding procedures, specifications, and schedules for each production-welding operation performed.

The best welding schedule for any weldment may be the result of years of plant practice or it may have been developed through laboratory tests.

Once the settings that result in the best welding conditions have been established, accurately measured, recorded, and made available to the set-up man, they can be used again and again as long as the characteristics of the weldment and its manufacturing environment do not change.

The use of a welding schedule so developed will allow for the greatest variation in welding conditions and manufacturing environment while still maintaining both production and weld quality at desired levels.

Quality Control

The operation must be carried through so that weldments of specified quality are made consistently. This could be called the principle of production-welding control. All factors involved in the production of a weldment whose deterioration would prevent the consistent production of a quality weldment at the lowest cost must be controlled.

An effective production-welding control system will provide for positive corrective action of unsatisfactory production-welding conditions with emphasis being placed on prevention rather than cure.

The major effort in production-welding control is aimed at the following:

1 Insuring that parts delivered to the welding operation are to specifications.

2 Maintaining equipment so that welds within specified limits are produced consistently.

3 Controlling the manufacturing process so that job specifications are maintained.

The inspection of parts before welding is a preventive measure which tends to insure that parts delivered to the welding operation are to specifications.

Elimination of material at receiving or in early stages of manufacture that is defective because of

(*a*) composition
(*b*) mechanical properties
(*c*) surface conditions
(*d*) discontinuities and impurities

saves the cost of handling, processing, and disposal of bad material.

Proper action by inspection during welding also helps. The checking of parts during set-up and adjustment and operation of a machine will indicate when acceptable weldments are being produced and will indicate how soon new adjustments must be made and how often maintenance operations of equipment are required.

By keeping records and providing reasons as to why parts have been rejected the inspector aids in determining why quality standards are not being met and assists in the correction of the harmful condition. The examination of machine settings being used, the observation of the procedures followed by the operator, and the sampling and inspection of the welds as they are made on a machine result in fewer rejects of welds and save repair and processing time.

The final inspection of the finished weldment will prevent defective goods from being shipped, will reduce product service costs, and increase customer satisfaction.

The maintenance of adequate equipment is the responsibility of the plant-maintenance department. An effective preventive-maintenance program is essential in keeping production-welding efficiency high and in minimizing the losses caused by equipment "downtime."

Preventive and corrective maintenance operations are handicapped if equipment capacity is too low or machine settings are improperly made. That is why control of machine adjustments and process specifications must be a part of any upkeep system. This is of such importance that some organizations have special welding process-control personnel who go from one welding operation to the next, checking machine settings against the welding schedules and process specifications of the part being produced.

Acknowledgments

The principles presented here have been formulated and developed through the combined efforts of a large number of men engaged in engineering, manufacturing, and training activities. Illustrations given were based on actual plant experience and operations.

Photographs used for illustrations were furnished through the courtesy of Buick Motor Division, GMC. Acknowledgment is made of the assistance of Mr. Stuart M. Spice, Welding Engineer, Buick Motor Division, GMC.

Bearings, Lubricants, and Lubrication

A Digest of 1954 Literature[1,2]

Journal Bearings and Bearing Materials

Newkirk and Lewis (1)[3] ran tests with oils of different viscosities to determine conditions of stable operation of cylindrical journal bearings above twice critical speeds. Two basically different phenomena are involved to which the terms "oil whip" and "oil-film whirl" have been applied indiscriminately.

An analysis of plain journal bearings based on the short-bearing approximation is presented by DuBois and Ocvirk (2). This eliminates the need for leakage factors. A method of estimating maximum bearing operating temperature is suggested and methods of evaluating the effect of elastic deflection and misalignment are included.

Jacobson, Charnes, and Saibel (3) developed an approximate solution for the end-lubricated complete journal bearing. Expressions were obtained for the load-carrying capacity, coefficient of friction, axial thrust, and rate of flow of lubricant. The solution is extended to the case where the oil inlet is circumferential.

Experiments by Kettleborough (4) on lightly loaded fully floating journal bearings show that a bearing with a freely floating bush provides the advantage of a conventional bearing with a larger radial clearance and more oil flow, hence lower temperature, but at the same time does not have the disadvantage of instability and oil whip.

Rightmire and Bonneville (5) point out that experience shows that a high-speed sleeve bearing subject to a fluctuating load develops damage similar to hydraulic cavitation. A study of this as relating to erosion has been made by multiple reflected waves; in particular the effect on an annealed copper surface by means of oblique-plane pressure waves was studied. The authors conclude that the probable cause of damage is due to cavitation.

Steller (6) has developed diagrams for load capacity, oil flow, friction, and temperature, for journal bearings with fluid friction. Numerical examples are given for hydraulic turbines, different types of pumps, and other practical cases.

Based on the earlier work of Stribeck in 1902, Vogelpohl (7) has given an explanation of the entire course of the Stribeck curve which characterizes the behavior of sliding areas in friction.

Thomson (8) discloses some experimental investigations into the effects of oil grooving, bearing material, and surface roughness, as well as the effect of use on lubricating oils and the performance of bearings. It is shown that oil grooves on the loaded side of the bearing reduce its load-carrying capacity, that tin-base bearing metals are preferable with mild-steel journals, and that safe bearing pressure is reduced by surface roughness.

Osterle and Saibel (9) have written a review of the work that they and their co-workers have done in the past few years. This work appeared in the Transactions of the Society under the general title "On the Solution of the Reynolds Equation for Slider-Bearing Lubrication."

The profile of stepped form is discussed again by Osterle, Charnes, and Saibel (10) who had previously extended the solution of Rayleigh for optimum load-carrying capacity to the case where viscosity is a function of the pressure. In this paper they consider the stepped slider where the viscosity is a function of the temperature.

Davies (11) obtains expressions for the minimum oil-film thickness and the maximum oil pressure in a film between a cam and a cam follower.

Boeker and Sternlicht (12) present a theoretical analysis of transitory fluid whirl for a rigid shaft running in a vertical position and an experimental verification of the theory for two types of bearings.

The power losses for elliptical and three-lobe bearings, both symmetrical and asymmetrical, are derived by Pinkus (13). Agreement is shown between theory and experiment.

Ball and Roller Bearings

Bearing Lubrication. V. B. Yardley (14) presented information on lubrication of rolling-contact bearings, including effects of dirt, moisture, and acids. Laboratory research on fats for lubrication of roller bearings was carried out by Mecocci and Abramo (15). T. B. Sansom (16) discussed lubrication and wear in ball-and-roller bearings. A. Fogg and J. S. Webber (17) investigated in the laboratory the effects of the kind of lubricant and method of oil supply on high-speed rolling bearings. Failures of roller bearings due to lubrication difficulties were reviewed by R. H. DuBois (18). W. J. Anderson and E. F. Macks (19) studied in a test rig a cylindrical roller bearing of the type used in jet engines; they determined the effect on operating temperature of the load and speed, and of the viscosity, flow rate, and inlet temperature of the oil.

H. Blok and J. J. Van Rossum (20) introduced a new bearing, consisting of a strip of foil stretched around half the circumference of a journal. The oil film formed between the flexible foil and the shaft was of uniform thickness and pressure. Experiments with a cellophane foil agreed with the theory. F. Osterle, A. Charnes, and E. Saibel (21) determined theoretically the behavior of a tilting-pad slider bearing subject to sinusoidal oscillation

[1] Report prepared by C. M. Larson, with the assistance of the ASME Research Committee on Lubrication. Contributing Committee members were: W. E. Campbell, H. A. Hartung, M. D. Hersey, S. J. Needs, B. G. Rightmire, E. Saibel, and S. K. Talley. The summary for the year 1954 was based on the Engineering Index references on Bearings and Lubrication.

[2] The digest of 1953 Literature appeared in Mechanical Engineering, vol. 76, September, 1954, pp. 739–747.

[3] Numbers in parentheses refer to Bibliography at end of paper.

of the pivot normal to the moving surface. Load and friction were given as functions of the amplitude and frequency of vibration. D. F. Wilcock (22) derived the mathematical relations for a pocket thrust bearing, in which the pocket oil pressures were built up internally by motion of the runner over a depressed pumping land.

G. F. Boeker and B. Sternlicht (12) developed a theoretical analysis predicting the threshold frequency for lateral oil-film whirl of an unloaded vertical shaft in a rigid bearing. Experimental results were compared with the theory. R. S. Sherwood (23) discussed the types of journal instability and the cause of oil-film whirl. Methods of eliminating whirl were given and a discussion of the effect of eccentricity ratio.

The flow of lubricant in a transparent journal bearing was studied by F. J. Kolano (24), by means of a finely devided fluid in suspension.

D. D. Fuller (25) reviewed the theory of air bearings. The low friction obtainable was emphasized and calculated for thrust and hydrostatic bearings. Other forms of air bearings were discussed. H. Drescher (26) investigated air-lubricated half and full journal bearings and thrust bearings. Experiments were carried out by T. L. Corey, H. H. Rowand, Jr., E. M. Kipp, and C. M. Tyler, Jr. (27) on a hydrostatic, air-lubricated, spherical bearing. Empirical expressions were derived for air flow and pressure in terms of load and lift.

George Sines (28) investigated the dynamic action of a small turbine rotor operating on porous bushings.

Hydrodynamic lubrication of roller bearings was treated theoretically by W. Lewicki (29) who developed an approximate algebraic solution yielding the minimum film thickness and the coefficient of rolling friction.

Bearing Design. Experimental cages of nodular iron and leaded brass for high-speed roller bearings were tested by W. J. Anderson and Z. N. Nemeth (30). The use of brass cages resulted in less wear of all components at high speeds, since cage slip was less than with nodular iron. Design considerations for cages were discussed.

A. A. Raimondi and John Boyd (31), in applying bearing theory to the design of centrally pivoted thrust bearings, discussed load capacity and effect of convexity.

Bearing Materials. E. F. Macks (32) described a new apparatus for evaluating the effects of several variables on the fatigue life of materials for ball bearings. Pressurized air was used to rotate balls in a raceway, giving stresses up to 70,000 psi and frequencies of application up to 10 million cps.

Six basic types of bronze-bearing alloys were discussed by J. L. Duchene (33) together with applications to roll-neck bearings and threaded bearings. J. B. Mohler (34) compared aluminum alloys with other bearing materials. Steel-backed aluminum bearings were discussed in detail. J. S. Kozacka, H. A. Erickson, H. W. Highriter, and A. F. Gabriel (35) investigated cemented-tungsten-carbide bearings run against journals of the same material. These were found to perform satisfactorily when extreme-pressure lubricant was used.

S. Tolansky (36) described the application of the light-profile microscope technique to the study of bearing surfaces prepared by different methods.

Bearing Failure. Various practical difficulties encountered in rolling-contact bearings were reviewed by J. Sparks (37), together with suggested remedies. Numerous examples of roller-bearing failures in rolling mills were cited by H. Ponnath (38), who also discussed the various causes of failure.

E. Crankshaw and W. Weinkamer (39) considered the visual analysis of several types of sleeve-bearing failure: fatigue, wear and scoring, corrosion and erosion.

Car Bearings. G. R. Andersen (40) stressed the need for more adequate lubrication of railroad-car journal bearings, discussing the desired viscosity characteristics of the oil and the problems involved in keeping the waste in good condition in service. J. W. Hawthorne (41) presented statistics on causes of failure in railroad-car journal boxes, showing that "waste grab" accounted for two thirds of all failures. He also considered possible improvements in design, manufacture, and maintenance. W. M. Keller (42) pointed out that railroad-car journal bearings operating without metallic contact experience a temperature rise due to viscous shear in the oil film and to pressure of waste against the journal. He emphasized the need for a single oil that can be used in summer and winter.

A wire-spring-type packing retainer for journal boxes of railroad cars was described by M. F. Brunner (43). A report on a similar device was given by H. J. Stewart (44). A waste container and retainer, made of synthetic rubber, was described by J. W. Hulson (45). Use of this device may improve the pumping action of oil through the waste under normal operating conditions.

K. Klingler (46) gave details of a device for eliminating the use of waste in railroad-car journal boxes. It incorporated a roller oiler sprung onto the journal and seals for both the lid and the rear of the journal box. Tests to date show encouraging performance. Another mechanism for the same purpose was discussed by V. E. McCoy (47). This device uses balls in a curved, continuous track to deliver oil to the journal as it rolls against the balls.

H. T. Rockwell (48) concluded from tests on freight cars that the off-center pull of brake rods has no appreciable influence on the skewing of the trucks and hence no effect on bearing wear.

Rolling-Mill Bearings. An outline of the development of roller bearings in Swedish rolling mills was given by A. Leufven (49). The oil-injection method of installing the bearings was especially mentioned. W. P. Snedden (50) discussed the application of tapered roller bearings on cylindrical and tapered roll necks.

W. Hensky (51) reviewed the application of plastic materials in rolling-mill bearings during the past 25 years. General principles for use of plastic bearings and further applications in rolling mills were discussed.

Bearings—Miscellaneous. W. L. Timmerman (52) described the various types of instrument ball bearings and discussed load, speed, friction torque, clearance, and lubrication of these bearings. Available types of roller bearings were reviewed by S. M. Weckstein (53), with special reference to selection and lubrication of bearings for oil-field equipment. K. N. Mills (54) presented the points to be considered by a machine designer in selecting roller bearings for specific applications. F. H. Stearns (55) described single and double-fracture split ball bearings and listed appropriate uses. One of the main advantages of a split bearing is the ease of installation and replacement.

L. L. McArthur and E. H. Kinne (56) described a procedure for determining the amount of stock to be allowed for finishing operations on roller-bearing parts.

O. Schenk (57) reviewed the effects of electric current passing through rolling-contact bearings. Typical examples of damage were described and remedial measures listed.

A new rolling bearing for heavily loaded toggles, as in crushers, was described by A. J. Roubal (58). This bearing has much longer life than conventional designs and requires no lubrication.

S. Baekstrom (59) studied the amount of fairly large silicate inclusions in acid open-hearth ball-bearing steel. Results agree with previously reported ones for basic electric steel.

G. Bunge, H. Erbe, and C. M. von Meysenbug (60) developed a method of estimating the lubrication regime in a journal bearing by observing the flow of electric current through the oil film. Four regimes were distinguished, covering the range from full fluid to extreme boundary lubrication. Several bearing tests were analyzed by this method.

Practical suggestions for installation of automotive journal bearings were offered by L. E. Schamaden, Jr. (61).

Lubrication of Industrial Plants. A. C. Keiser, Jr., E. E. Perso, W. H. Mandy, and M. S. Clark (62) reviewed the severe conditions found in steel mills and the precautions to be taken in the selection of oils and operation of lubricating systems. W. W. Williams (63) discussed methods of lubricating machinery in steel and tin-plate works, especially roll-neck bearings and gears, as well as hydraulic systems and maintenance problems.

The effect of different types of lubricants on the coefficient of friction in brass rolling under service conditions was investigated by J. W. Johnson (64).

K. P. Powers (65) reviewed the practical aspects of textile-mill lubrication, with special reference to lubricant selection.

Thrust Bearings

Theoretical investigation of the Reynolds equation as applied to slider-bearing lubrication is continued by Osterle, Charnes, and Saibel (10). The new case considered is that of the stepped slider with adiabatic lubricant flow. To date nine conditions have been analyzed in these studies (See Digest for 1951, 1952, and 1953). A survey of the contributions, with material abstracted therefrom, is the subject matter of another paper by the authors (9).

Experiments with a water-lubricated, tilting-pad thrust bearing are reported by Abramovitz (66). Abnormal increase of friction was observed when the rubbing speed exceeded what appeared to be a critical value and indicated possible turbulence in the water films between runner and shoes. An analysis is made of the experimental data based on the work of G. I. Taylor.

Oil streamlines in bearing films are traced by a semigraphical method developed by Kettleborough (67). This method, which can be applied to either thrust pads or journal bearings, is illustrated by a typical calculation.

An experimental investigation into the operation of tilting-pad thrust bearings has been carried out by Kettleborough, Dudley, and Baildon (68). Determinations of film pressure distribution, film geometry, friction characteristics, and temperature distribution have been made for a range of speeds, loads, operating temperatures (viscosity), and pivot positions. An attempt is made to correlate these results with existing theories.

Investigation of blisters on the babbitted faces of large thrust-bearing shoes has been made by Baudry, Gunther, and Winer (69). The study revealed that such blisters resulted from the accumulation of hydrogen at the steel-babbitt interface; the hydrogen having been absorbed at high temperatures during manufacture of the steel. The maximum level of hydrogen content to insure freedom from blisters was determined and processes for removing hydrogen from the steel were developed.

Licht and Fuller (70) have investigated a parallel-plate thrust bearing using air as the lubricant. Equations are developed for load-carrying capacity, film thickness, pressure profile, and volume of air required for a typical bearing. Comparison of theoretical and experimental values shows that within the limits of test data behavior of this bearing can be predicted with good accuracy.

Compressed air is used as a substitute for a conventional thrust bearing (71) between a heavy rotating plate and a fixed base plate on a multiple-spindle drill. This novel application was made by tool designers of the Solar Aircraft Company.

A. A. Milne (72) points out that when viscosity varies across a lubricant film due to temperature gradient, the Reynolds equation is no longer valid and the expression for friction and pressure must be rederived. This applies when lubricants that are not Newtonian fluids are used in fluid-film bearings; as the shear stress varies across the film so does the local viscosity. The change in viscosity is likely to be particularly marked with a plastic lubricant such as grease but a similar effect will be noted with structurally viscous oils. The paper suggests a theoretical treatment for determining the behavior of such viscous lubricants as are not Newtonian, with particular reference to greases. As the theory is sufficiently general to include plastics as well as fluids, it is proposed to use the term "rheodynamic lubrication." Both slider and journal bearings are considered.

Automotive Lubricants

Automobile Engines: *Deposits.* McNab, Moody, and Hakala (73) present results of extensive studies of combustion-chamber deposits. They find that deposits contain contributions from both fuels and lubricants, and improvements in both are needed. Lubricants contribute to deposits in proportion to their molecular weight or volatility; multigraded lubricants consequently show advantage over conventional lubricants in keeping deposits down. Contribution to combustion-chamber deposits by crankcase oil was also found by Overcash, Hart, and McClure (74) to be related to base-stock distillation characteristics. Low-boiling oils gave less deposit in field and laboratory tests, consequently reducing octane requirement increase.

Testing. Georgi (75) reported on dynamometer tests involving 18 oils to evaluate fuel consumption. He concluded that viscosity under operating conditions is the significant lubricant property governing gasoline mileage. Proprietary oil additives were found to have no effect in reducing engine friction. Test methods and instruments for evaluating the effect of combustion-chamber deposits on knock and deposit ignition are described by Hall, Warren, and McCullough (76). Their studies show that aromatics in gasoline give deposits of greater deposit-ignition tendencies and that the use of phosphorous fuel additives and multigrade lubricants tend to reduce this type of ignition.

Valves. Construction and operation of modern hydraulic valve lifters were reviewed (77). Their inherent advantages, and the demands they place on engine lubricating oil, were pointed out.

Automotive Fuels: *Detonation.* Comparing a detergent

and a nondetergent oil in a group of 17 privately owned cars, Bennett and Landis (78) found that detergent oil resulted in a fuel requirement three octane numbers lower than nondetergent oil. In laboratory tests, the difference was six to eight octane numbers in favor of detergent oil.

Diesel Engines: *Wear.* Application of radioactive piston-ring technique to diesel-engine testing has been made in Great Britain (79).

Friction. In studying the frictional characteristics of automobile brakes, Sinclair (80) found that brake squeal occurs when the coefficient of friction decreases as sliding velocity increases. Certain types of lubricants which give lower static than kinetic coefficient eliminate squeal in the laboratory but are not sufficiently durable for service in automobiles.

Lubricants. Condensations of five papers presented at the Institute of Petroleum Summer Meeting at Llandudno (May, 1954) are reprinted in Scientific Lubrication (81). Robertson and Barrett discuss diesel-engine and drive-mechanism lubrication in "Land Transport by Rail." The problems of crankcase lubrication are treated by Holmes and White in "Lubrication Problems in Road Transport." Hoare, Parker, and Tyson, in "Lubrication of Aircraft," summarize present status of lubricating engines, airframes, and hydraulic and mechanical control elements. "Lubricant Requirements of Sea Transport," by Illingsworth, deals with the problems of adequate lubrication for steam and diesel engines and steam turbines. Hunt, in "Future Trends in Quality of Fuels and Lubricants Used in Transport," considers that improvements in crankcase and gear lubricants for different types of engines will be forthcoming.

Lubricating Oil. Reviewing developements in engines, oils, and fuels over the past 25 years, Bartholomew (82) predicts that continued advances in oil technology will be needed to meet the demands of higher compression ratios and more powerful engines.

Additive Compounds. Sargent and Kipp (83) report that activated alumina shows merit for the maintenance of nonadditive oils in engines burning scrubbed natural gas. Granular material was found to be superior to prefabricated blocks. A review of motor-oil additives is given by Arnold (84), with emphasis on the role of heavy-duty oils in minimizing engine wear.

Automobile Engines. A review of a number of SAE papers of multigraded motor oils concludes (85) that these lubricants can show advantages in oil consumption and fuel economy.

Frazier, Klingel, and Tupa (86) report the results of laboratory and road studies of straight mineral oils and oils containing viscosity-index improver polymers. They found that oil consumption was proportional to the 300 F conventional viscosity, while gasoline mileage correlated well with 210 F viscosity at a shear rate of 3×10^5 sec^{-1}. This accounts for observed better gasoline mileage without increased consumption for polymer-blended oils. Laboratory and road tests using SAE 10W, 30, and 10W-30 grade motor oils are described by McReynolds, Britton, and Quigg (87). Oil consumption was again found to depend primarily on viscosity at 300 F.

Moore, Kent, and Lakin (88) point out that most automobile trips are short and that oil temperatures do not have time to rise to an equilibrium value. Under these conditions, multigraded lubricants are shown to give easier starting, better fuel economy, less engine wear, and lower octane requirement increase. Appreciable gasoline economy for multigraded oils over conventional oils is reported by Moore, Kent, Lakin, and Mattson (89). Although some savings can be shown for long trips with warm engines, they increase markedly as trip length and as engine temperature decrease.

Summarizing extensive field tests with SAE 10W-30 motor oil, Miller and Hartmann (90) show that substantial improvements in fuel and oil mileage can be realized with multigraded oils over conventional SAE 30 oil. Better idling characteristics, more rapid starting and warm-up, quieter engines, and more acceleration and power have been reported by users comparing the two types of lubricant. Bidwell and Williams (91) found that multigrade lubricants gave less octane requirement increase and slightly greater gasoline mileage on short trips than did conventional lubricants. The authors caution that consideration must be given to intake-valve deposits, valve-train wear, and base oil viscosity if satisfactory engine lubrication is to be maintained.

Georgi (92) proposes revision of present SAE viscosity classifications, since certain multiple grades cannot fit some of the grades they span. He also points out anomalies at low temperatures in the use of Saybolt and kinematic viscosimeters and the ASTM viscosity-temperature chart, particularly with multigraded lubricants. Raymond and Socolofsky (93) trace the development of multigrade lubricants and suggest that lubricant research not be limited by arbitrary classifications or specifications, but that it be guided by performance requirements of engines.

In evaluating valve-train-wear problems, Bidwell and Vermaire (94) conclude that certain oil additives can accelerate failures. While design features and materials of construction have some influence, their test results seem to indicate that lubricant quality, as regards boundary lubrication and effect on corrosion fatigue, is the important factor in solving these problems. Havely, Phalen, and Bunnell (95) report that distress of cams and valve lifters is strongly influenced by engine design and the metallurgy of the mating parts. In laboratory testing a number of oils in three engines with several different lifter-cam combinations, hardenable cast-iron lifters with a sulphur-phosphorous additive in the oil appeared to give least pitting and scuffing. Yowell, Weisel, and Risher (96), in reporting the results of extensive field tests on automotive-engine lubricants, conclude that valve train wear is profoundly influenced by the metallurgy of the parts. Although some improvement in performance can be made through better antiwear additives, this can be far outweighed by improvement due to changes in the metallurgy of parts, particularly camshafts and valve lifters. Wood (97) points out that new test procedures are required to study sticking of valve lifters and wear of cams and cam followers. Such tests are proposed, and it is concluded that specially selected additives in the crankcase oil can help solve these problems.

The inadequacy of MIL specifications tests for modern passenger-car crankcase lubricants is noted by Finnigan and Pfeifer (98). They propose other tests, found to be useful in studying the problems of valve-lifter sticking, valve-train wear, engine cleanliness, and flow properties of multigraded oils.

In a symposium on engine lubrication, Mougey (99) points out that corrosive wear is an important factor in determining engine life. Recently the need for high film-strength properties in oils has become more apparent. Junge (100) classifies bearing failures as due to fatigue,

scoring, corrosion, and erosion and shows photographs of bearings failed by each of these mechanisms. Hamer, Tutwiler, and Weisel (101) review the demands of modern engines on lubricating oils and show how proper selection of base stocks and additives can extend engine life and improve performance.

Testing. Larson (102) reports the results of extensive fleet testing of base oil and oils of different detergency levels. Oils of high additive level were consistently superior to base oils in reducing engine deposits, ring and cylinder wear, and oil consumption. These factors all led to appreciably lower maintenance costs. Field tests are cited by Penfold and Klein (103) to support the use of high-quality oils for military service. The authors believe that L-1 and L-4 tests have proved generally suitable for qualification purposes, although these tests may need to be modified or supplemented for unusual conditions. Snyder, et al. (104), review some of the extensive laboratory test programs that are part of lubricant development and point out that many of the properties tested are not covered by Army specifications. Field tests form an extensive and important part of the development effort.

Reclamation. A plant for reclaiming used railroad diesel lubricating oils is in operation in Canada (105).

Lubrications: *Aircraft Engines.* Goodding and Hatch (106) emphasize the importance of mechanical design in lubricating turbojet engines. Solid oil jets provided by multiple-element pumps comprise the basis of systems that have achieved success in the field. Tourret (107) discusses the factors influencing the formation and stability of foam in aviation crankcase lubricants and points out that good mechanical design along with the proper selection of foam inhibitors are essential elements in controlling foam. A general review of the lubrication requirements of aircraft gas turbines shows that diester oils give promise of excellent performance (108). Requirements of lubricants for aircraft gas-turbine power plants are outlined by Bedell (109). He shows how synthetic lubricants compare with petroleum lubricants in the salient properties and points out the success achieved by a synthetic lubricant based on a diester.

Diesel Engines. A new oil-control ring design embodies two stepped rings in a single groove (110). This construction is said to allow effective chrome plating of the lands. Barrett (111) points out that low-viscosity oils can affect fuel economy in diesel engines. Road tests show that heavy-duty oils with chrome-plated top rings can extend ring and liner life to nearly 200,000 miles.

Oil-change periods for diesel engines should be dictated by oil condition, as shown by examination, and consideration of the type of service involved. Moody and Gibb (112) give methods of examining used oils and interpretations of the engine conditions represented. McKeown (113) states that properly used oil-conditioning equipment can cut engine wear in half.

Locomotives. Ninety new steam locomotives for South African Railways are being provided with automatic lubricators of latest design (114).

Oil Filters. James (115) finds that small dirt particles in crankcase oil cause wear in proportion to their concentration, principally in bearings and lower cylinder areas. Dirt entering the engine through the carburetor accelerates compression ring and upper cylinder wear. Beynon (116) describes development work in oil filters.

Petroleum Products: *Standards.* Part V of the 1953 Supplement to the 1952 Book of ASTM Standards lists latest revisions of standards on fuels, petroleum, aromatic hydrocarbons, and engine antifreezes (117).

Power Transmission. Roach (118) reviews the effect of various types of solid contaminants on bearings of different design and materials of construction.

Gear Lubrication

The lubrication requirments of gears are described by L. J. Collins (119) from the viewpoint of a gear engineer. It is not yet scientifically understood how gear teeth have been lubricated successfully under loads approximating 180,000 psi, while journal bearings not uncommonly experience difficulty at 3000 psi. Essential factors beside choice of lubricant are the accuracy of tooth spacing; surface finish appropriate to different operating conditions; tooth modification near tip to prevent scraping off the film; and sliding velocity as affected by tooth design. Five common types of distress are pitting, abrasive wear, scoring, burning and rolling or plastic flow. Illustrations are given from service experience, showing how to correct or prevent such difficulties.

The ASLE series on practical lubrication has been continued by H. W. Winkler in his article on "Open Gear Lubrication" (120). After reviewing historically the many types of greases and other gear lubricants that have been used, and describing the characteristics of each type, the author goes on to explain modern methods of application, including the use of solvents. Avoidance of high temperatures and contamination are advocated. Here will be found an excellent qualitative report on the diversified and often conflicting requirements met in lubricating open gears.

A timely warning is given by an article in *Power* (121) against expecting too much from bench tests for load capacity of gear lubricants. The Almen, Falex, SAE, Four Ball, and Timken tests are described in parallel columns. Their contrasting principles of operation are strikingly brought out by line drawings. Although the hoped-for correlations with full-scale performance have never been realized in sufficient measure to warrant ASTM acceptance, the tests are known to be of some value in laboratory development work and in checking products for uniformity.

The lubrication of nonmetallic bearings and gears is discussed by A. E. Williams (122). Wear rates of gears have been measured successfully by F. L. Schwartz and R. H. Eaton (123) using the radioactive method. The functions of the lubricant in driving pinions and other steel-mill equipment are discussed by W. Williams before the Institution of Production Engineers (63). Gear-lubrication practice of the electrical industries in Germany is described in a convention report (124). Types of failure and research results on heavy-duty gears are summarized in another article drawn from well-known sources previously reviewed (125). This article serves as a good introduction to the broad subject of research on gear lubrication.

Another general summarizing report was presented by W. Pohl (126) at the Lubrication Conference in Liege. In reviewing the more important investigations of the past 20 years the author makes it clear that two distinct schools of thought have grown up. One considers that the lubricating film between gear teeth must be so thin that only boundary friction is significant. Viscosity, in the hydrodynamic sense, plays a negligible part and scuffing occurs when the temperature flash, or local

temperature rise, exceeds a critical value, different for different oils. The other school believes hydrodynamic action predominant up to some very high load, after which scuffing occurs owing to sudden film failure unless prevented by chemically reactive EP lubricants. The author then describes experimental work conducted at the Thornton Research Center, previously reviewed in the "Digest." Load capacity decreases as the 2/3 power of the pinion speed for light oils, as predicted for boundary friction, but is less affected by speed at higher viscosities. The load capacity increases with increasing viscosity grade, but gives widely different graphs for any one viscosity at different temperatures. For a given oil, the load capacity remains nearly constant over the temperature range from 40 to 110 C (say, from 100 to 230 F). While the facts are difficult to explain by either school of thought alone, the author concludes from the present rate of progress in lubrication research that the performance of gears will be more accurately predictable in the near future.

A comprehensive and original study by A. Cameron on the causes of surface failure in gears (127) is of outstanding interest in the literature of 1954. Elementary hydrodynamics accounts for the formation of the oil film with increasing speed, and its observed characteristic of a maximum load capacity, diminishing with further increase of speed owing to the heat generated by fluid friction. Theory further indicates a pressure distribution in the film substantially the same as given by the Hertzian formula for elastic contact of unlubricated cylinders. Mean pressures as high as 4000 atm (nearly 60,000 psi) may be reached in the loaded area of the film. At these pressures both the adiabatic heating of the film and the effect of pressure on viscosity must be considered.

The author employed electrical resistance measurements as the most logical technique for investigating conditions in this inaccessible loaded area. A disk machine was built for the purpose. Corrections were made for certain departures from Ohm's law. It was then found that a complete film was formed at much lower speeds than would be expected from conventional hydrodynamic theory. Two possibilities are suggested by way of explanation—(*a*) Maxwell's relaxation concept, oils behaving momentarily like solids when rapidly deformed, and (*b*) a rigid adsorbed layer as postulated by Heidebroek and others (reviewer here calls attention to the boundary-film investigations by S. J. Needs, ASME Transactions, 1940).

Although scuffing is correlated better by temperature flash than by any other method, the exact mechanism has not been discovered. A theory here proposed is that scuffing may be a type of pressure welding effective after the surface temperature has reached the softening point of steel in the neighborhood of 250 C. In his electrical experiments the author had observed that the total amount of energy dissipated at the contact is a constant, whether made up of electrical or mechanical components. This tends to support the pressure-welding hypothesis.

Pitting is discussed in the light of microphotographs obtained during the author's experiments. It was concluded that cracks usually form at the surface and are often due to pitting. It was found that the pitting of lubricated teeth is correlated with the Hertzian stress calculated from tooth loads. This fact is offered to confirm the theoretical finding, mentioned previously, that the pressure curve of the oil film approximates the Hertzian curve. Cameron's paper is accompanied by discussions contributed by other well-known investigators, including T. B. Lane, F. T. Barwell, and H. Blok.

Metalworking Lubrication

The Production Engineering Research Association of Great Britain (PERA) has investigated in detail the performance of a selected group of soluble cutting oils and has now published that part of its work which deals with corrosion of cast iron (128). It finds considerable differences between the eleven soluble oils tested, with the clear soluble oils being somewhat better than those having a milky appearance. Corrosion is slightly less at 1/10 water dilution than at 1/15 or 1/25 dilution. Of the three cast irons tested, no one was more liable to corrosion than the others. Steel chips left on cast-iron surfaces promote rusting and PERA employed a test for corrosiveness based on this fact. It recommends removing cutting chips from all important machine surfaces prior to an idle period to avoid corrosion; protection can be increased with a grease film rubbed on the surface.

Hays and Hudec (129) propose a test for cutting fluids in which wear of a tool blade is measured under conditions of adequate fluid flow. The tool blade under test does not cut the work; it is merely pressed against a freshly cut surface of the work. The "cutting speed" is 100 fpm, and the tool is loaded at a constantly increasing rate (10 lb/min on the loading arm). Under the conditions they employed, a sulphochlorinated additive reduced wear of the tool by about 70 per cent relative to the wear with plain mineral oil. Flood lubrication reduced wear by 21 to 33 per cent relative to a film of oil.

Hoggart (130) critically reviewed earlier theoretical treatments of lubrication in wire drawing and employed a "thermocouple die" to investigate copper-wire drawing. The die diameters were 0.085 and 1.0865 in., half angle, 6 deg, and drawing speeds ranged up to 1280 fpm. He concluded that a lubricating oil (Thuban K) gave quasihydrodynamic lubrication up to 300 fpm drawing speed and hydrodynamic lubrication above this speed on the basis of the change of friction with speed. With emulsions and the same die, lubrication was quasi-dynamic up to 480 fpm. Between this speed and 765 fpm, friction increased abruptly and the change in friction was related to the temperature at which copper stearate melts, which is about 94 C. With a second die, the coefficient of friction was constant between 250 and 690 fpm and lubrication was concluded to be boundary. Ringing and wear of the die entrance were attributed to cavitation due to turbulence and high vapor pressures. He concluded that selection of lubricants should be on the basis of lubrication mechanism and not on friction measurements alone.

Barnes and Cafcas (131) employed a tensile-test machine, having a maximum draw speed of 20 ipm, to investigate lubricants for cup-drawing, wire drawing, and rolling. Soft and pliable dry films were found to be superior to hard and brittle dry films for redrawing aluminum cups. In fluid lubricants, drawing work increased with increased viscosity. Tendency to scratch or to give smooth bright surfaces depended on chemical factors, and some emulsions were equivalent in this respect to the most viscous neat fluids. Drawing force in the test rig placed lubricants in the same sequence as power requirements in a brass rolling mill.

Friction against die walls limits the density that can be obtained in compacting metal powders. Sheinhartz, et

al. (132), find that die-wall friction can be measured by the force developed on a bottom punch in an independently supported cylindrical die. For an 0.775-in-diam die, —325 mesh stainless-steel powder and 0.772-in. punches, the lowest wall friction was obtained with stearic acid applied as a slurry in CCL_4 and allowed to dry before use. There is an optimum particle size for graphite and molybdenum lubricants; low particle sizes give high friction and large particles do not adhere to the die walls. The ratio of transmitted (lower punch) to applied (upper punch) load is constant, over a range of 2000 to 20,000-lb applied loads, for a given die and metal powder. Relationships are developed for calculating transmitted loads for different die cross sections and weights of metal compacts.

Snow (133) proposes four evaluations for the selection and control of soluble oils and their emulsions for hot-rolling aluminum and aluminum alloys. Emulsion stability is observed after prolonged heating at 95–100 C, with make-up water being added as required. Staining is checked by placing 1 or 2 cc of emulsion in a depression in an aluminum sheet and heating. Emulsion life is largely determined by deterioration of surface finish of the rolled sheet. Wetting properties are evaluated by the Draves test which measures the time for a standard cotton skein to sink in the emulsion.

Boundary Lubrication

General. In a review of lubrication trends, Zisman (134) discusses the relation to performance of the chemical and physical properties of various classes of lubricants and additives. Lines of research are suggested to improve lubricants through a better understanding of the mechanism by which these properties are involved in lubrication and friction.

Present knowledge of fretting corrosion is reviewed by Campbell (135). He emphasizes the fact that fretting is primarily wear, the corrosion being a result of the wear. The nature and extent of the corrosion is dependent on the nature of the materials in rubbing contact and of the surrounding atmosphere. Methods of minimizing fretting and suggestions for future research are discussed.

Davies (136) shows that lubricating oils in a modern high-speed internal-combustion engine must have some ability to lubricate under boundary conditions. An air-gage method to measure lubricant thicknesses, accurate to 0.0005 in., is described by Pinto (137). Features of magnetic brakes and magnetic power clutches are described by Ande (138) and by Martin (139). A Republic Aviation Test Report (140) shows tables and graphs to illustrate studies of the friction in cable-pulley systems. The size of dirt particles in oils should be kept below the minimum oil thicknesses between moving surfaces, according to Roach (141).

Kühnel (142) reviews the recent German gearing literature. The accumulated information permits the assignment of each material to assure optimum performance. The data are to appear in "Handbuch für Gleitlogerwerkstoffe" (Springer-Publishers, Berlin Göttingen-Heidelberg, 1952).

Solid Friction and Solid Lubricants. King and Tabor (143) show that for sliding on a rock-salt crystal the overwhelming effect is plastic deformation and shearing of surface layers. Experimental evidence suggests that the adhesion mechanism developed for metals and plastics applies to rock salt. The friction between surfaces, freshly cut in air and in inert atmospheres of various combinations of metals, are studied by Machlin and Yankee (144). Particular attention is directed toward the behavior of titanium. The degree of welding of freshly cut titanium surfaces to other metals at room temperatures is independent of atmosphere (argon, air, nitrogen) and of time of exposure up to 24 hr. Iron and copper, however, show a marked reduction after less than 5 min exposure to air. Thus the authors suggest that film on titanium has little resistance to penetration or wear in frictional contact. Since oxide film on titanium has weak adsorptive forces toward lubricants Rabinowicz (145) suggests chemical modification of the oxide.

Rabinowicz, et al. (146), made a statistical study of friction force for a copper sphere on a copper plate for varying loads and surface conditions.

The terms "clean and smooth" surfaces as associated with surface conditions of test specimens in studies of frictional phenomena are clarified, and the effect of vibration on the coefficient of static friction is discussed by Claypoole (147). The coefficient of static friction is significantly reduced by vibration.

In an interesting theoretical analysis by Archard (148) relationships involving real area, conductance, and load for plane surfaces in contact are deduced. The same author suggests a theory of wear which expresses the relationships of wear to load under conditions of elastic and plastic deformation. Application of the theory to existing experimental data indicates that wear product is removed in "lumps" rather than as atomic layers.

Bowden and Thomas (149) measure temperatures at the point of rubbing contact by infrared-radiation measurements. They found that the maximum temperature rise is limited by the melting point of the solid. Oxidizable metals attain higher temperatures due to "burning" of the metal. The transformation temperature of alpha to gamma iron is utilized by Agarwala and Wilman (150) to show that temperatures of 900 C are obtained with a single stroke of emery at hand pressure.

Mathematical analyses of frictional forces at variously shaped metallic junctions are made by Green (151) and confirmed, in some cases, by experiment. Lodge and Howell (152) conclude that the friction-load relation between elastic solids, in any particular experiment, is dependent on the geometric arrangements of the contacting surfaces. This conclusion is neatly borne out experimentally by Hirst and Lancaster (153).

Billington (154) cites the chemical and physical advantages of colloidal graphite as a lubricant. Brown (155) points out that paint-application techniques can be used to put on bonded-to-metal film-type lubricants. Not all layer-lattice crystalline materials provide good lubrication according to Peterson and Johnson (156). On the contrary, some low shear-strength materials without such structure are effective. The formation of a film on both surfaces seems to be the necessary condition for good lubrication. Molybdenum disulphide was found most effective.

Boundary and EP Lubrication. Rabinowicz (157) studies the friction between pairs of steel, zinc, and lead with copper palmitate as lubricant. Fatty acids are found by Tarrant (158) to provide far superior lubrication, as determined by friction measurements, at low speeds (1/4 iph) than oils containing extreme pressure additives such as sulphur and chlorine compounds. At temperatures up to 600 F synthetics prove to be better lubricants than comparable petroleum types according to Murray,

Johnson, and Bisson (159). Phosphates and silicates were particularly good. In compounded oils, lubricating effectiveness is a function of tri-cresyl phosphate concentration and not of oxidation inhibitor or viscosity-index improver concentrations.

White (160) reports that the shear strength of soaps below 70,000 psi decreases as the carbon chain lengthens. The reverse is true at higher pressures to 250,000 psi. Increased temperature reduces shear strength.

Properties of Lubricants

Lubricant Manufacture. A new plant (161) for the manufacture of high-grade lubricants, built by Compania Shell de Venezuela, consists of high vacuum-distillation unit, propane deasphalting unit, furfural extraction unit, solvent dewaxing unit, and hot clay-contacting unit. The plant will produce 100,000 metric tons of lubes per annum. Jones (162) discusses how hydrofining can be applied to refining of low-cost lubricants to replace acid treating or how it may be applied as final process to insure uniformity of color and other properties of lube base stocks prepared by extraction and, where necessary, dewaxing. Steps for treating lubes at Sarmia are described. Products show improved physical and chemical properties and process provides flexibility in quality control.

Wharton (163) discusses a quick method of calculation when two or more viscosity-index improvers are used. Blending charts were developed to aid in the selection of improvers, estimation of viscosity, and viscosity index of oils containing them. Tabulated data are given on comparison of observed and calculated viscosity index and viscosity of oil-additive blends.

A process (164) disclosed in U. S. Patent 2,674,568 employs silica gel percolation to separate low VI components from those having high VI; paraffinic and aromatic naphthenes employed in lubricating oil of patent may be characterized by the following formula: $M(n_D^{20} - 1.4750) < 8$ in which M is average molecular weight and n_D^{20} is index of refraction at 20 F of naphthenes using sodium D-line.

Plummer (165) reports the details of a 15-million-pound-capacity grease plant at Clarkson, Ontario, featuring centralized control of the operations, facilities for weighing the grease-making ingredients, hot-oil heating, and cold-oil cooling of kettle equipment. Boner, Rinearson, and Nofsinger (166, 167) discuss the specific use and arrangement of equipment of Clarkson refinery at Toronto, discussing such phases as the lubricating-grease plant, operation control, storage, process heating, saponification equipment, dehydrating, milling, types of thickeners used, lubricating fluids used, special grease characteristics, and the application of greases. Field (168) shows that major reductions in clay requirements can be made by distilling lube-oil stocks into light and dark fractions before treatment.

Poti, Gent, Pomatti, and Levin (169) have devised an infrared method, based on the fact that 4-methyl-2, 6-di-tert-butylphenol can be quantitatively eliminated from oils by heating. The need for having the base oil for the determination is eliminated and it is applicable to both new and used oils.

Testing and Analysis. Numerous new ASTM specifications (170) have been published for test methods and their definitions, motor and aviation fuels, lubricating oils, turbine oils, and bituminous materials. The new section summarizes changes made in ASTM standards in 1953.

Ellis (171) reviews and compares the latest trends in modern viscometry of high-grade lubricants, selection of viscometrical equipment, the problem of converting of the units, temperature effects on viscosity, viscosity-temperature relationships, and methods employed to determine the viscosity of lubricants not classified under normal recognized standards. Hersey and Hopkins (172) compiled data from scattered sources, reduced to comparable basis by adoption of suitable definitions and units and presented in convenient form for practical use. The work includes review literature, conclusions of engineering interest, and further research needs. Clark (173) assembled data from the ASME project on high-pressure viscosity applied to test feasibility of predicting viscosity at high pressures from room-pressure measurements at 100 and 210 F. Dow (174) studied the extent to which the empirical ASTM Chart-Walther method reproduces viscosity-pressure-temperature data by examining characteristics of viscosity isobars on chart and significance of intercept and slope functions of Walther equation. The analysis covers 32–425 F and 100,000-psi range.

Gates, Bergstrom, Hodgson, and Wendt (175) discuss a technique for rapid oil analysis for used oils taken from gasoline, diesel, and gas engines. It is a modified form of paper chromatography using soft neutral analytical filter paper. The method also employs a special color indicator formulated for use with oils which are alkaline when new. Costantinides, Policastro, and Arich (176) discuss the analysis, through absorption on silica gel, applied to study and control of solvent refining of lubricating oils. The methods presented may be applied to the control of solvent-extraction units. Courtel and Bernelin (177) have applied optical methods to the examination of lubricating greases.

Williams (178) has applied ultraviolet rays in testing materials such as oils. Fluorescent examination gives useful indications regarding origin and processing of mineral oils and makes it possible to grade different fractions by their fluorescence. Girelli, Paleari, and Siniramed (179) have devised an improved technique to save time and materials in lubricant research and testing laboratories. The method is based on "compensation line" which allows elimination of runs of loads lower than the initial seizure load. The laminar-flow properties of oils and greases passing through tubes of circular cross section, studied by method in which radial velocity distribution could be directly observed, are presented by Mahncke and Tabor (180).

Chamberlin (181) reports on color standards.

An automatic oxygen-absorption unit (182) for oil-oxidation tests is described, illustrated, and procedure outlined.

Baker, Jackson, and Booser (183) developed a number of short-time evaluations to simulate closely actual equipment operations providing satisfactory grease lubrication. Rozsa and Zeib (184) apply spectrographic analysis for determination of the amount of metal worn from engine parts and contaminants causing the wear.

Using electron microscope, Peri (185) describes its use and preparation of oil specimens for examination. The performance of detergent-type oils only were described. Pope and Hall (186) discuss the types of tests used for evaluating used lubricants and give examples to illustrate their advantages and limitations.

Steinle (187) describes the chemical stability of

lubricating oils in hermetically sealed systems in contact with SO_2, freon-12, and methyl chloride. A review of the functions that a good lubricating oil should perform are discussed by Gruse (188). He further states that no one test, or combination of tests, can give complete indication of quality.

The object of the work by Francis (189) was to develop a method for the structural group analysis of saturated hydrocarbons of high molecular weight, such as those occurring in the lubricating-oil fractions of petroleum.

Wharton (190) discusses new monographs for predicting the viscosity index and viscosity where two or more viscosity-index improvers are incorporated. The chemical stability of lubricating oils in service is discussed by Nichols (191).

Fuller and Lea (192) describe the absolute, kinematic, and saybolt systems of viscosity measurement, and the conversion from one system of units to another.

The API Research Project 42 (193) prepares, purifies, and studies properties of model hydrocarbons in lubricating-oil range to afford better understanding of behavior of oils.

Chamberlin (181) shows the characteristics of the Redwood scale, IP color scale, ASTM scale, and Indian color scale as applied to lubricating oils.

Additive Compounds. Improvements of fuels and lubricants are discussed by Beard (194) by use of additives as developed during the past 30 years. The physical classification of the additives, their economic significance, and the relationship to corrosion problems in the oil industry is presented.

Arnold (84) states that oxidation of hydrocarbons present in oils can be reduced by modern refining methods which tend to eliminate naturally occurring oxidation inhibitors. Two mechanisms of action of inhibitors are presented (*a*) inhibitors may react with activated oxygen molecules, or (*b*) deactivation of metal surfaces in contact with oil.

Sargent and Kipp (83) have investigated various grades of alumina for maintenance of gas-engine crankcase oils. The lubricant used in all tests on spark-ignited engines burning natural gas as fuel was solvent-refined, straight, naphthenic-base oils. Unusually promising results were obtained.

The practical evolution of additive chemistry was discussed by Musgrave (195) covering the fields of evaluation and testing of additives, performance tests, future testing procedures, effect on bearing surfaces, hypoid-gear lubrication, lubrication of diesel engines, development of long-service lubricants, and possible future developments.

Criddle (196) shows surface-active properties of rust-preventive additives in terms of their ability to make oil spread on water. Five surface-chemistry experiments involving oils are described in order to explain the spreading tendency, additive depletion, and other phenomena displayed by antirust composition.

Gavlin, Swire, and Jones (197) studied the scope and potential utility of pour-point depressant additives. They bear on essential structural features of pour-point depressants and mechanism of pour-point depression.

The stability and mechanism of settling of carbon black in organic liquids with or without detergent additives, together with viscosity studies of nonsettling dispersions are discussed by Gardner, Nutt, and Mohtadi (198).

Solid Lubricants. Sonntag (199) discusses how molybdenum disulphide simplifies extreme pressure lubrication problems. He points out the special usefulness of molybdenum disulphide in combating galling and seizing of oxidation-resistance metals, how it adheres to metal surfaces providing lubricity from —100 to 750 F in air and up to more than 2000 F in the absence of air, and its industrial uses. Better chemical and thermal stability of molybdenum disulphide as compared with certain other lubricants are presented by Kay (200). He discusses its application to cutting tools, showing how it is used as an additive to normally applied coolants and its contribution to extending the life of cutting tools.

A new process (201) bonds molybdenum disulphide to surfaces to which it is applied, achieving a lower co-efficient of friction, greater thermal and chemical stability, and a greater load-carrying capacity. The chemical and physical properties of molybdenum disulphide and its use as an inhibitor for fretting corrosion are given by Spengler (202).

Rabinowicz (203) discusses various phases of solid-film lubrication illustrating the mechanism of lubrication, frictional and wear requirements, inorganic-film lubricants, layer lattice films, soft-metal films, long-chain organic materials, solid-film synthetics, erosion of lubricant film, and self-generation of lubricant layers. He also shows the applications of various dispersion-type lubricants. A comparison of the principal features of phosphate coatings, molybdenum disulphide, and silicone greases is given in the *Mechanical World* (204).

A manual in nonchemical language by McGregor (205) gives the history of early investigations and chemical development of silicones, describing the physical properties and applications of fluids, compounds, lubricants, resins, rubber, and other silicone products. Resen (206) shows how the use of a silicone defoamer in an acid gas-absorption unit prevents foam formation. Various uses of silicones are described, relating to lubricating oils, wax molding, electrical insulation, protective coatings, and the foaming of residuals.

Background history of aviation turbo oil 35 (207), a lubricant for gas turbines developed by the Esso Petroleum Company, is discussed. Brandt (208) discusses the use of synthetic lubricants in four different turbine-engine airplanes. The lubricants were PRL-3313, PRL-3161, MIL-O-6081, and the new synthetic WS-2211. PRL-3313 affected rubber, plastic, finishes, etc., to a greater extent than PRL-3161.

Synthetic lubricants, developed to fill military needs for lubricants with improved performance characteristics, are discussed by Millett (209). He provides a list of the principal types of synthetic lubricants that have been evaluated for military use.

Dasey (210) discusses the characteristics and production of petroleum-derived and synthetic lubricants. Campbell (211) considers physical properties in evaluating solid lubricants in applications where organic or fluid lubricants fail, especially where long storage or inaction precedes operation. Physical and chemical properties of certain esters, ethers, and their derivatives are compared with those of petroleum products by Moreton (212). Teeter, Gast, Ball, and Cowan (213) describe a program of evaluation of domestically produced vegetable oils as sources for synthetic lubricating fluids.

Research relating to applications of esters as lubricants, their physical properties, and performance results are presented by Cohen, Murphy, O'Rear, Ravner, and Zisman (214).

Reclamation and Filtration. Guidance to the selection and use of equipment for removing insoluble materials, or both insolubles and oil-soluble oxidation products, is presented by McKeown (215). He also reviews (216) the equipment available for oil filtration and purification, and the installation methods and practices for maintenance of lubricating oils.

Lubricating Grease. Armstrong (217) discusses factors affecting the performance of high-temperature greases. Boner (218) reviews the basic factors of the fundamental composition and capabilities of lubricating greases together and outlines some of the broad service conditions.

The properties of lubricating greases, prepared by using oxidized wax with sodium, calcium, lithium, aluminum, and mixed sodium-calcium, are described by Kirk and Nelson (219).

Insulating Oils. Investigations by Schofield and Carver (220) show no financial advantage under Chicago conditions in reclaiming and inhibiting old transformer oil. The results confirm tests previously reported by Halperin and Adler of Commonwealth Edison Company for inhibited oil in old breather-type transformers.

Plant Practices. The influence of soluble oils on the surface finish in hot-rolling of aluminum and its alloys is presented by Snow (133). The various factors affecting surface finish of the hot-rolled blank is considered. Desirable properties of soluble oils for hot-rolling is discussed, including emulsion stability under all conditions. Perry (221) considers the cold-rolling process with respect to the function of the rolling oils, classes of rolling oils, and their methods of application. The types of rolling oils considered are for steel, copper, brass, and aluminum.

The evaluation of nonflammable fluids as steam-turbine lubricants is discussed by Browning and Ipsen (222). Because of the need for nonflammable lubricants, a survey of available hydraulic lubricants was made but none of those tested was found suitable in its present form. Clark (223) discusses turbine oils and turbine lubricating-oil systems, and and Zuidema (224) shows how the make-up rate affects the life span of turbine oils.

A new lubricant called "Rollene H," superior to palm oil, which eliminates electrolytic cleaning prior to annealing for plating operations, is described by Bible (225).

General. A broad discussion of lubrication and the respective roles of the lubrication engineer and lubrication chemist, with particular reference to the latter, is presented by Evans (226).

Zisman (134) shows lubrication trends with respect to friction and wear research on metallic solids, polar-type liquids, absorption effects, soap properties of lubricants, sulphur and chlorine compounds, hydrocarbon properties, ester lubricants, and detergent additives. In another paper he discusses the evaluation of additives and reviews progress made in lubricating greases (227).

Frank, Blackham, and Smarts (228) summarize a continuation of spontaneous ignition, studies based on the use of spray injection rather than dropwise addition to ignition chamber. They describe investigations of various types of lubricants and observations regarding effect of structure, additives, and metal surfaces on spontaneous ignition temperatures.

Lubricants available for particular jobs where high temperatures are involved are described in the *Western Machinery & Steel World* (229).

The problem of removing minute quantities of wax from unblended lubricating-oil base stocks following conventional filtration has been solved and was presented by Thornton (230).

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Briefing the Record

Abstracts and Comments Based on Current Periodicals and Events

J. J. Jaklitsch, Jr., *Associate Editor*

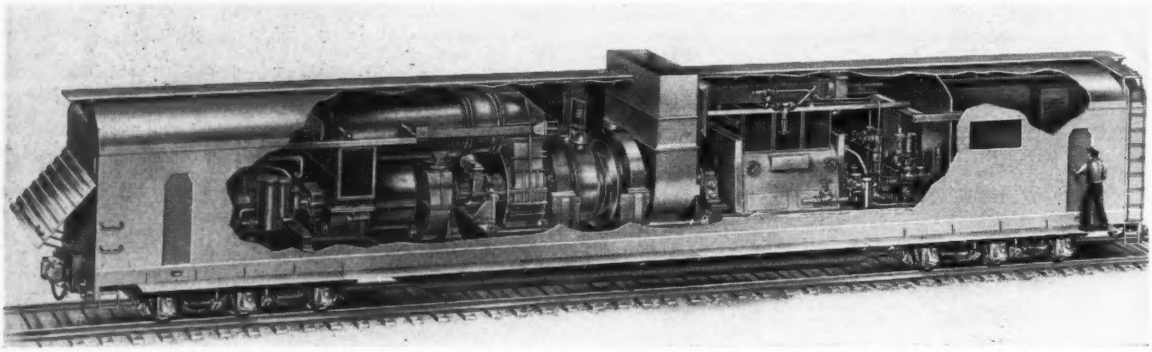


Fig. 1 Cutaway of Clark gas-turbine mobile power plant mounted in a specially designed railway car. Opening at left end is for air for the lube-oil coolers. Opening through roof in center of car is for exhaust from the turbine. Starting at left is the diesel engine used to start the unit, the gas turbine, the generator, exciter, fuel pumps, and the control room.

Mobile Gas-Turbine Power Plant

Development of a mobile gas-turbine power plant of unique design was announced recently by Clark Bros. Co. (one of the Dresser Industries) of Olean, N. Y. This Turbo-Mobile Power Plant is capable of developing 5500 kw of electricity. The complete plant is mounted in a single railroad car and can be placed in operation within 24 hr after its arrival at a site.

The unit, which has been built for the Bureau of Yards and Docks of the United States Navy, is designed specifically as a compact, mobile source of a large amount of electric power which can be used if an emergency should occur. Even though it is an emergency unit, the power plant is of heavy-duty design and can be operated continuously no matter what the duration of the emergency may be.

A second unit rated at 6200 kw is being manufactured for the Comision de Electricidad in Mexico. It will be placed in operation next spring.

The Comision Federal de Electricidad, together with the private companies in Mexico, are primarily integrated in metropolitan areas. The large distances between these cities and areas requiring power have resulted in many sizeable but relatively isolated power systems.

It is not feasible to provide stand-by or back-up capacity for each of the power systems. Similarly, it is not economical to build transmission lines in order to interconnect all of the areas in use. Mobile power has, therefore, been the best answer. Mobile steam and diesel plants have been used but they are not an entirely satisfactory answer. The ideal plant should be of a size that will be most effective. This requires 5000 to 10,000 kw.

Portable diesel-generator sets are large and heavy with respect to their output.

A mobile steam plant such as the 10,000-kw trains built for the United States Navy during World War II, has been used in Mexico. Although the rating is satisfactory, the water requirements, the number of cars involved, and the complexity of putting the unit in operation make it a less desirable application.

The Clark Turbo-Mobile Power Plant, however, eliminates all of these basic objections. It is satisfactory from a size viewpoint, it does not require water, and it may be moved and placed in operation in hours. Furthermore, these units can be operated by one man, and if necessary, they could be remotely operated.

Another important use for Turbo-Mobile Power Plants is to meet emergencies which frequently arise from natural causes such as floods, fires, tornadoes, hurricanes, earthquakes, and many others. These natural disasters often occur suddenly and with devastating results. Power failures can often affect not only the disaster areas, but nearby areas as well. Mobile power plants, strategically located throughout such areas, could quickly make power available wherever it is needed.

In the event of hostilities, turbo-mobile power plants of this type would be well suited to be moved in on ships to base areas. In this country mobile power would be the answer to keeping key manufacturing plants operating in the event of major power failure. The essential facilities of large cities, such as water pumps, hospitals, etc., could also be kept operating.

An emergency of less ghastly, though highly important nature, is to meet the power requirements of fast-expanding areas. The trend toward decentralization in our rapidly growing communities can result in a distribution problem, particularly in new areas which are beyond the major power-distribution system. The mobile unit will provide immediate power until the load growth warrants an extension of the major system.

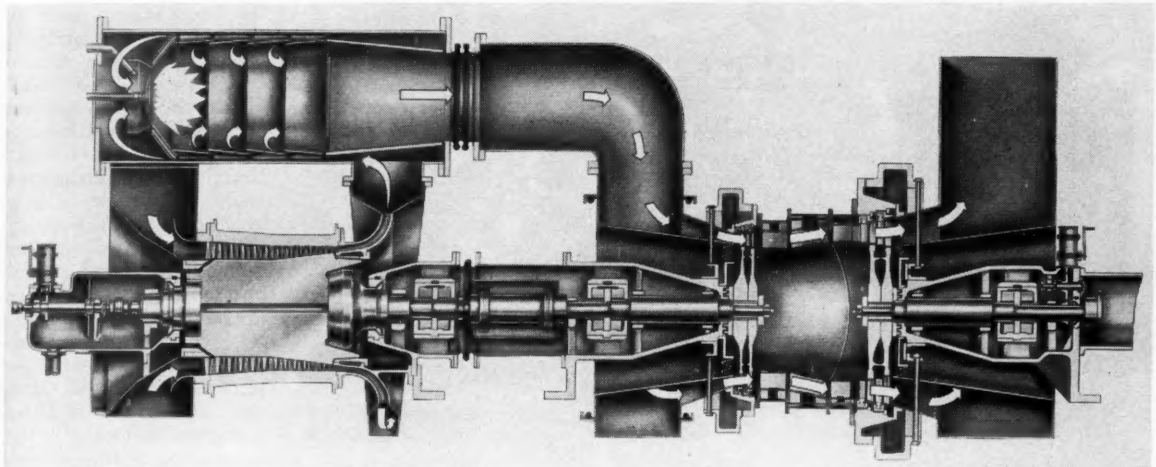


Fig. 2 Simplified cross section shows flow of air and gas through the gas turbine. Air enters the axial compressor at *lower left.* The 13-stage unit discharges air into the combustion chamber at *upper left* where it is mixed with either liquid or gaseous fuel and burned. The hot gases enter the high-pressure turbine, *center*, which turns this turbine and also turns the axial compressor connected to it. Next, the hot gases enter the low-pressure turbine, *right*, which is connected to the load. Subsequently, the gas discharges through the roof of the car. The unit is started by a diesel which is connected to the extension shaft of the axial through a torque converter and clutch. As soon as the diesel has brought the axial up to a high enough speed to furnish sufficient air for combustion, the diesel disengages and the unit is self-sustaining.

The gas turbine used to drive the generator in the Turbo-Mobile Power Plant is equally well suited to the drive of centrifugal compressors in the refining, gas transmission, process, and general industry. It is specifically designed for continuous, long-life operation either with or without regeneration.

Clark's gas-turbine power plant is a complete self-contained 5500-kw unit rated at 80 F ambient temperature up to an altitude of 1000 ft. The prime mover is a simple, open-cycle, dual-shaft, series-flow gas turbine direct-driving a two-pole synchronous generator. The complete plant with auxiliaries, controls, fuel storage and handling, auxiliary engine-driven generator, station switchgear is mounted on one rail car suited to freight or passenger-train use on standard AAR gage track.

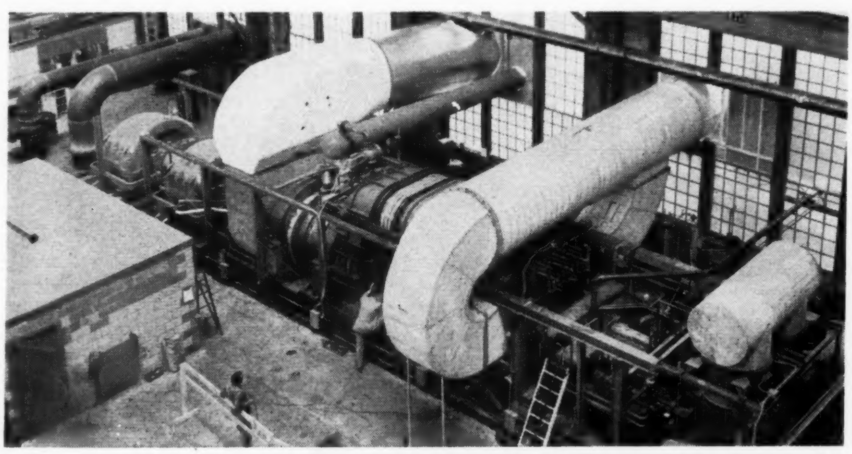


Fig. 3 Clark gas-turbine power plant is shown here undergoing test, prior to mounting in car. No part of the outer surface has a temperature exceeding 200 F.

Gas-Turbine Performance Characteristics

The gas turbine consists of an axial-flow compressor and axial-flow turbine with two shafts. The first (high-pressure) turbine consisting of two stages drives the axial-flow compressor supplying combustion air. The second turbine running independently drives the load generator directly at 3600 rpm. The following is the performance of the machine at various load conditions:

Loading	Output Kw	Heat rate	Station efficiency
Full load	5500	18,000	19
3/4 load	4125	20,600	16.6
1/2 load	2750	34,200	13.2

Facilities are provided in the fuel system for operation of the gas turbine with residual fuel oils. In order to minimize the effects of vanadium attack, blade fouling from ash deposit, and other faults arising from the combustion of this type of fuel it will be necessary to limit the turbine inlet temperature to 1150 F. The expected maximum station output when operating at this limiting turbine temperature is 3200 kw.

Gas-Turbine Components

Combustion air is supplied by a 13-stage axial-flow compressor at a pressure ratio of 4.25 and a flow of 100 lb per sec. The com-

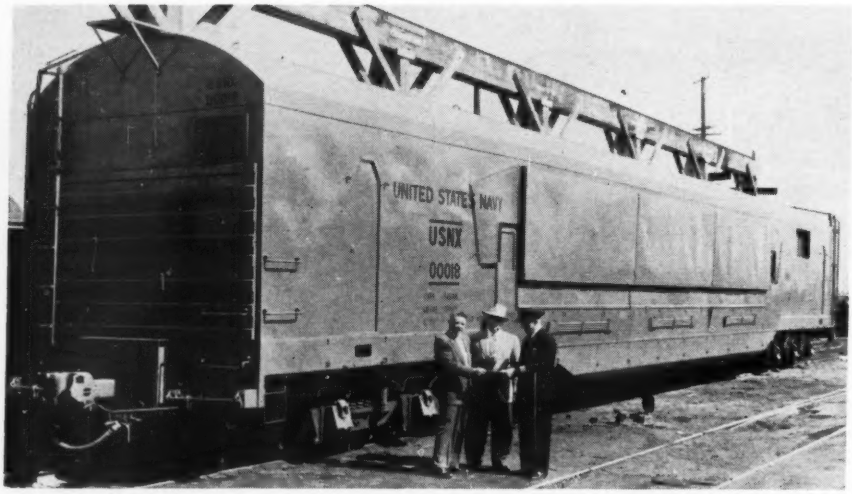


Fig. 4 Car used for mobile gas-turbine plant is of special design to assure maximum support for the turbine-generator. It can be operated on any standard-gage railroad in regular freight or passenger-train service. Filter "sheds" on each side of the car which serve to filter the air inlet to the axial can be folded lightly against the side of the car for transit.

pressor is driven through a flexible coupling by the high-pressure turbine at 5000 rpm.

Combustion of the fuel is accomplished in a single, highly stable contraflow combustion chamber. The single combustion chamber used gives the simplest possible arrangement without the matching difficulties of multiple chambers. Combustion-chamber liner changes are not required during the life of the turbine. Three fuel atomizers are supplied. To facilitate maintenance the nozzle installations are so designed that any area may be shut off and removed for cleaning or replacement while the turbine is in operation.

The turbine consists of two separate units, the high-pressure turbine which is a two-stage unit operating at 5000 rpm driving the axial compressor, the low-pressure turbine which is a two-stage unit operating at 3600 rpm driving the load generator.

The separate turbine design allows mounting of the two subassemblies on two separate bases. A flexible duct connecting the high-pressure turbine is easily removed. This area then provides access to both turbines, either of which may be completely inspected by removal of individual wheels and nozzle rings.

The turbine is designed for normal operation at an inlet temperature of 1350 F. Temperatures in excess of 1350 F may be maintained for varying percentages of operating time.

The unit will be mounted on the car on two independent sub-bases. One will support the compressor and first turbine, the other will support the second turbine and generator-exciter combination. Each sub-base is supported at three points selected to assure minimum deflections. This three-point suspension is designed to provide correct degree of freedom at each joint and will thereby permit normal deflection of the basic car structure without causing any shaft misalignment. Relative movement due to car deflections between their respective sub-bases will be readily accommodated by the flexible duct installed between turbines.

Only minor preparation at the site before start-up is required. The brakes of the car are set and the wheels blocked to prevent the car from rolling. In addition, the filter sheds are opened, the turbine exhaust duct is opened, and fuel and electrical connections are made. The power plant is now ready for start-up. Only one trained operator is required to start and operate the plant. At start-up the auxiliary diesel engine which is used to bring the turbine up to sustaining speed is started. This unit also provides all of the power for the electric auxiliaries. When sustaining speed is reached on the turbine, the starting engine automatically disengages. After turbine warm-up, the main generator speed is adjusted to synchronize with the auxiliary generator which is then shut down. The main circuit breaker is closed and the turbine control switched to automatic.

A normal shutdown is accomplished by reducing the turbine power setting gradually to idling and opening the main circuit breaker. The auxiliary diesel is restarted and the electrical load of the auxiliaries is taken over by the diesel-driven auxiliary generator. The main unit can then be stopped by pushing the stop button.

Railway Car

The railway car will be constructed with two major side trusses essentially like Prott trusses. Each truss will be made with an extra-heavy lower chord member to carry longitudinal coupler forces as well as concentrated loads from sub-base connections. Cross bracing is

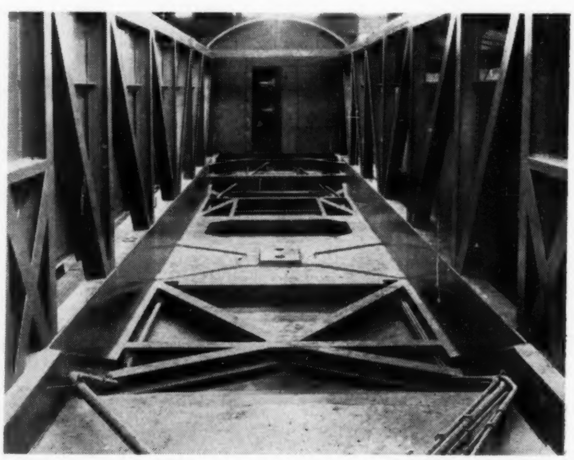


Fig. 5 Interior view of car shows the unusually heavy trussed-type construction used to support the 245,000-lb load. The support of major components is on three points. This assures accurate alignment, independent of car flexure.

installed at lower chords in the form of bulkheads between turbine components and provides fuel and lubricating-oil tankage. Upper-chord cross bracing is provided as an integral part of the roof trusses and is made removable to facilitate maintenance work. The car will be mounted on two 3-axle trucks designed in accordance with AAR specifications and for the maximum center-plate loading imposed by the car and all equipment. Snubbers and draft gear will be so designed that accelerations will be limited to $2g$ in any direction. Since no center still may be installed because of unit size, coupler forces will be transmitted through horizontal shear members to the lower-chord members of the side trusses.

Filter area for compressor air and generator cooling, and catwalks for access to various components, are contained in extendable car sides. When in transit, these sides fold up to enclose the car and in that condition are within the profile limits. Main lubricating-oil coolers and the auxiliary engine cooler are located in the end of the car. The main fan and emergency fan are located in opposite sides of the car and discharge into a common plenum chamber, thence through the radiators to the outside. The roof is made in four main sections and one exhaust section which are bolted to the top chords of the side trusses. During operation the section over the turbine exhaust is opened. For normal maintenance, roof sections need only be opened up over the particular area in work. For major overhaul where external crane facilities are available roof sections may be completely removed. All switch gear and controls are housed in the control room in the generator end of the car which will be acoustically and thermally insulated from the turbine compartment.

Pipe Insulation

A NEW pipe insulation which combines maximum insulating efficiency and condensation protection for lines operating at low temperatures, or at alternating cycles of high and low temperatures, has been announced by Owens-Corning Fiberglas Corporation, Toledo, Ohio.

Known as Fiberglas White Dual Temperature Pipe Insulation, the product, for use at temperatures from —120 to +250 F, includes a factory-applied vapor barrier which prevents condensation and provides an attractive, white, slightly crinkled surface.

The pipe insulation is made of fibrous glass bonded with a thermosetting binder and the jacket is composed of a five-ply laminate including an asphalted Kraft paper for the inner surface, a bleached Kraft paper on the outer surface, and the two enclosing a 0.001-in. thickness of aluminum foil. This jacket has a vapor transmission rating of less than 0.01 perms.

The low perm rating helps prevent condensation on piping when insulation is of recommended thickness since moisture cannot penetrate to a surface cold enough to cause it to condense.

The pipe insulation will fit all standard sizes of pipe to 33 in. and copper tubing to 6 in.

For pipe sizes up to and including 12-in. diameters, the insulation is furnished in semicylinders with the vapor barrier attached. For pipes of diameters greater than 12 in., it is supplied in three segments to 28 in., in seven segments to 33 in., and the jacket is applied separately. All sections and segments are 3 ft long.

The pipe insulation, fastened in place with metal bands, is available in nominal thicknesses of 1, $1^1/_2$, 2, and $2^1/_2$ in. All conform to simplified dimensional standards or "nesting" sizes, permitting multiple-layer build-up of insulation to any desired thickness.

Other advantages of the pipe insulation, according to Owens-Corning, are as follows:

The white vapor-barrier jacket provides a neat appearance and does not need painting under dry conditions, but can be painted if desired. The softly crinkled texture of the jacket resists soiling and looks well for a long time. Because its stable inert fibers of glass will not rot or corrode, the pipe insulation will stand up under long service.

Easy to handle, ship, and apply because of its lightweight, the pipe insulation will not crack or shatter under stresses normally encountered under these conditions. It has no odor, will not absorb odors, and offers no sustenance to insects, vermin, or mold growth.

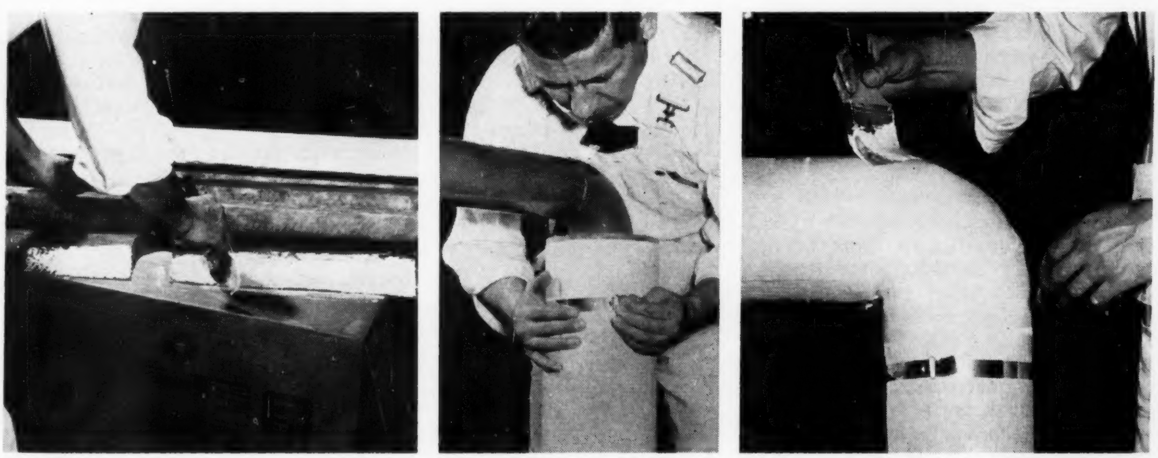


Fig. 6 A lap cement, *left* photo, is used to seal the longitudinal and transverse joints of the vapor-barrier jacket of the Fiberglas White Dual Temperature Pipe Insulation prior to its application. *Center* photo shows application of pipe insulation. The lap is sealed and bands installed to fasten the insulation in place. With fittings covered with tape and brush-coated with finish, *right* photo, fiberglas pipe insulation provides an attractive appearance.

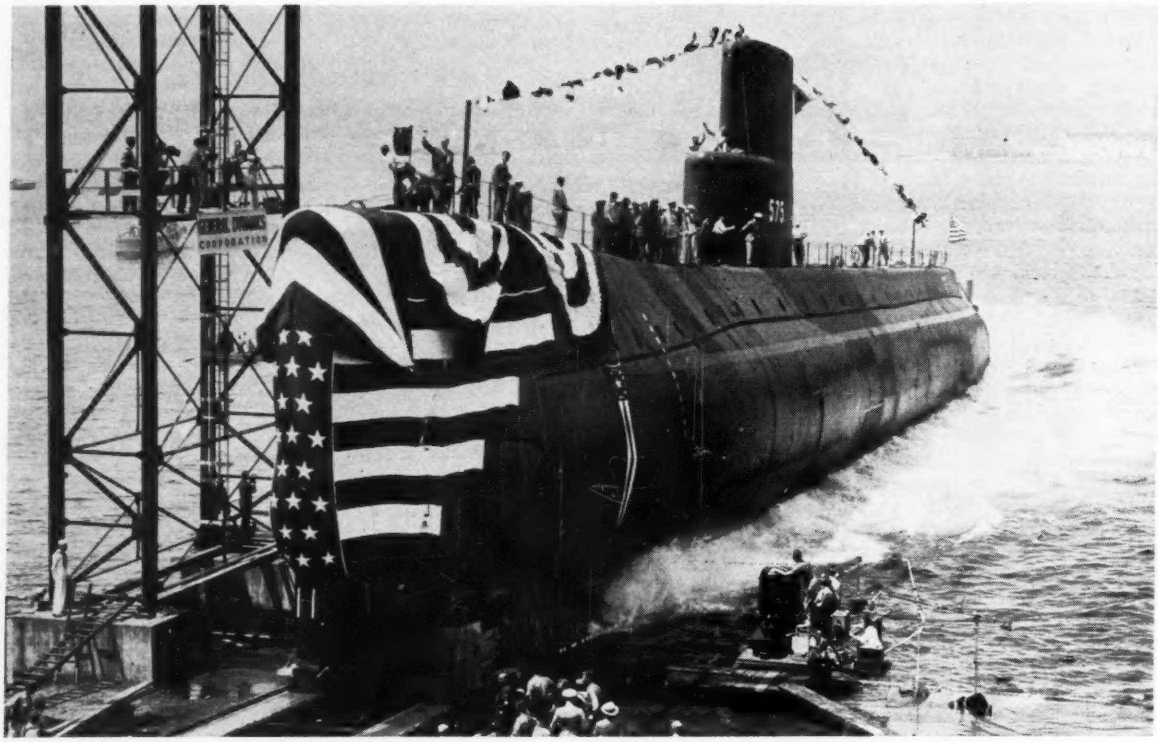


Fig. 7 The atomic sub *Seawolf* is shown sliding into the water of the Thames River as she is launched at Groton, Conn. About 330 ft long and about 27 ft wide at its widest point, the *Seawolf* will have a speed of more than 20 knots. Other vital facts: Number of crew, about 100; displacement (surface), about 3000 tons; main propulsion, reactor-fired steam turbine (sodium-cooled reactor); auxiliary propulsion, storage battery and diesel-electric drive; number of propellers, 2; daily capacity of water-distilling plant, 5000 gal; cost (exclusive of reactor), $32,700,000.

Atomic Submarine "Seawolf" Launched

On July 21, 1955, the second nuclear-powered submarine, USS *Seawolf*, was launched at Groton, Conn. As she slipped down the ways into the Thames River very few of the more than 20,000 guests were aware that the keel plate for the third submarine, yet unnamed, had been laid in the adjacent slipway some four hours earlier. It was the same slipway on which the keel plate of the world's first atomic submarine, the USS *Nautilus*, was laid on June 14, 1952.

Speaking before a distinguished audience at the launching of the *Seawolf*, The Hon. Charles S. Thomas, Secretary of the Navy, saluted the Navy's pioneering in the nuclear-propulsion field.

"What has already been learned," he said, "and will be learned from the operation of the *Nautilus'* and *Seawolf*'s power plants has already been most helpful for atomic power in American industry and commerce. The successful development of nuclear-propulsion systems for naval ships has solved numerous problems which industry and commerce can adopt: New metals, new controls, new materials, new safety devices, new processes, new pumps, and new instruments."

"To show the Navy's avid interest in nuclear propulsion," Secretary Thomas said, "the Navy has seven different nuclear-reactor projects. The nuclear plants of the *Nautilus* and the *Seawolf* were purposely made competitive partly to determine which is the better power plant and partly to exploit the rapidly advancing technology of nuclear propulsion."

The Submarine Intermediate Reactor, SIR, Mark B, is being readied for installation in the USS *Seawolf*. It is the first submarine reactor to use liquid sodium as a coolant and the first to use neutrons of intermediate velocity.

The reactor was designed and is being constructed at the Knolls Atomic Power Laboratory under the supervision of the Atomic Energy Commission and the Navy. The Laboratory is operated by the General Electric Company for AEC.

The G-E engineers say that the *Seawolf* reactor has these advantages:

1 Since sodium does not boil, except at extremely high temperatures, the reactor coolant system does not have to be pressurized.

2 Sodium is an excellent conductor of heat.

3 Sodium, when its oxygen content is low, is noncorrosive to steels at operating temperatures.

4 Sodium is a good electrical conductor; because of this it can be circulated by a magnetic pump which has no moving parts.

5 Intermediate spectrum neutrons place fewer restrictions on the structural materials which can be used in the reactor core. For example, stainless steel can be utilized. This is because high-energy neutrons are not readily absorbed by conventional metals.

During his talk at the launching, Secretary Thomas revealed that this year two naval shipyards would build nuclear submarines for the first time.

It was announced also by John Jay Hopkins, chairman and president of the General Dynamics Corporation, that 1955 would see the dedication of "what we believe to be the first privately financed laboratory in the world devoted primarily to basic nuclear research." The foundation for a part of the laboratory in the Groton yards has already been built. Another part of the project would be elsewhere, according to a reliable source.

Admiral Lewis L. Strauss, chairman of the Atomic Energy Commission, disclosed that the land-based prototype of the *Seawolf's* atomic power plant, located at West Milton, N. Y., had simulated a transoceanic crossing before the submarine herself was launched. "That," he said, "represents the equivalent of an underwater voyage from St. Johns, Newfoundland, to Dover, England. This, I am told, compares to four hours at full power as the qualifying time for new, diesel-powered submarines. The *Seawolf*'s speed is officially 'greater than 20 knots submerged.'

"This prototype of the *Seawolf* power plant has achieved further renown. On Monday of this week [July 18] at West Milton, I had the privilege of throwing the switch which sent thousands of kilowatts of power surging into transmission lines to serve homes, farms, and industries of upper New York State."

Francis K. McCune, Mem. ASME, vice-president and general manager, Atomic Products Division, General Electric Company, speaking on "Harnessing a Dream," outlined some of the historical data of the past ten years of the atomic age, paying tribute to W. L. R. Emmet, who produced the Navy's first turbine-electric drive for the collier *Jupiter*.

Stressing co-operation, he said, "Together, working with one aim in mind, a team—consisting of the Navy, the AEC, General Dynamics, and General Electric—produced this strikingly advanced nuclear submarine."

"And to those who have worked so hard and so long," he said, "to make this atomic dream a reality—and believed when others refused to believe—this is a dramatic victory—the beginning of significant practical application of the energy of the atom. But let me hastily add that, as these men well know, the most startling thing in the atomic field has been the tremendous speed with which the dream of yesterday becomes the commonplace fact of today...and the ancient history of tomorrow."

Mrs. W. Sterling Cole, wife of the former chairman of the Joint Congressional Committee on Atomic Energy and Representative of New York, christened the ship, which went down the ways smoothly with her skipper, Comdr. Richard B. Laning, aboard.

Among the guests who witnessed the launching of the *Seawolf* were Governor A. A. Ribicoff of Connecticut and Rear Admiral H. G. Rickover, Hon. Mem. ASME, one of the Navy's staunchest supporters of nuclear-propelled ships.

As Secretary Thomas said in conclusion, "This launching is also symbolic of the new American Navy of which the *Seawolf* is a small but important segment. Throughout our fleets, accent is being given to the rapid adoption of nuclear propulsion to submarines, surface ships, and aircraft. Fresh emphasis is being given to the concept of using ships as mobile bases—moving air bases, missile launching bases—bases upon which our national power can be projected wherever necessary. Jet seaplanes are being developed that can range the oceans of the world. Guided-missile ships are replacing conventional ships, and missiles are replacing guns themselves. A stable of atomic weapons, air to air, air to ground, and surface to surface, is being fully assimilated."

Electronic Fire Watcher

Television is now to be used to protect our precious national forest preserves. Electronic fire watchers, mounted on lonely lookout towers deep in the forests, relay television pictures of the surrounding areas back to forest headquarters, where the rangers can spot fires as soon as they start. This will help to prevent the huge costly holocausts that annually destroy $60,000-000 worth of timber. The device was demonstrated re-

Fig. 8 Newest weapon to fight America's annual $60,000,000 loss from fires is Raytheon Manufacturing Company's electronic fire-watch system. Rotating TV camera spots fire and beams the picture, via microwave, to headquarters. Two or more unattended towers can obtain cross-bearings and pin-point the blaze.

cently by Raytheon Manufacturing Company at a convention of the Forestry Conservation Communications Association at the Fort Sumter Hotel, Charleston, S. C.

The equipment works without the use of wires or cables. A microwave beam carries the picture from the TV camera in each lookout tower, across miles of rugged timberlands, lakes, and mountains, to the forest headquarters. There a series of television monitors show the observers the scenes picked up by the cameras. The cameras rotate continuously, but may be stopped, started, or reversed by remote control—again through the use of a Raytheon microwave beam.

As each camera rotates, it records not only the forestry scenery, but an azimuth scale on the glass dome. Thus, if a forest fire is spotted, the camera may be stopped with its lens trained on the fire, and the scale reading, or "bearing" may be noted. When bearings are obtained from two or more towers, the location of the fire may be pin-pointed on a map by the simple process of triangulation.

Since the very advent of television, forestry officials have predicted that the TV camera would eventually become a powerful ally of the forest ranger, giving him an "all-seeing eye" to help keep watch over vast areas of wilderness. The limiting factor, however, has been the expense and impracticability of stringing miles and miles of costly coaxial cable from the lookout towers to headquarters. Such cables would be subject to falling trees or branches, high winds, ice storms, and forest fires themselves. The Raytheon microwave link eliminates the need for wires.

Officials of the Waltham, Mass., electronics firm stated that the link, known as the KTR-100, is a specialized version of a device originally designed for the television industry. It consists of suitcase-sized units which are attached easily and quickly to the TV camera in the field, allowing the camera crew to photograph such events as ball games, news events in the streets, and other on-the-spot scenes. A lightweight aluminum parabolic reflector or "dish," is mounted on a tripod, preferably on the roof of a nearby building, and is connected to the camera and KTR-unit in the street below. The link picks up both the sound and picture, and feeds both to the dish, which beams them out on one waveband, simultaneously, to the receiving unit which may be located as far as 25 miles away. There the sound and picture are separated electronically and may be fed through a regular studio to the local broadcasting tower.

The entire microwave equipment is small and light enough for one man to carry, yet despite its portability, it can be used for permanent installations such as in the fire lookout tower. Under the most severe conditions of use, it has proved itself capable of operating unattended through broiling summer heat and subzero cold with a minimum of maintenance. The pictures that it relays are clear, steady, and highly detailed—enough so that forestry men can expect it to help catch poachers, firebugs, and other lawbreakers occasionally. The pictures are unaffected by atmospheric conditions or other common forms of interference.

Wearable Contour Polishing Wheel

A NEW type of wearable coated abrasive contour wheel has been introduced by the Behr-Manning Division of Norton Company at Troy, N. Y.

The wheel is said to permit polishing of complex contours with an efficiency not attained before. Substantially an all-coated abrasive wheel, it is capable not only of being shaped to the work, but also of holding that shape as it wears. Designed for use on straight-line and rotary automatic-polishing equipment, it is equally adaptable to semiautomatic fixtures where it requires no special attachments or other accessory equipment.

Significant advances which the new "Kon-Toor" wheel offers for automatic polishing at production rates include: Development of fine finish on involved contours; maintenance of original contour through the working life of the wheel; elimination of one or more buffing stations; and the obvious reduction in cost which results from the wheel's long life and consequent minimum of down time.

Increased Production

In the plant of a Midwestern appliance manufacturer who has been co-operating in a year-long test program, for example, 180-grit Kon-Toor wheels 7 in. wide have each worn three to four weeks and applied a first intermediate polish to as many as 350,000 contoured toaster sides. Compared with abrasive belts previously used, production increased 15 per cent and abrasives cost dropped nearly 50 per cent.

This manufacturer also found, as a by-product of the smooth wiping action and the light pressure exerted by the new wheel, that his work was running cooler than before, so that heat distortion was eliminated. Also, the wheel consumed less power, a fact which may become important as new straight-line, rotary, or semiautomatic-polishing departments are installed.

Wheel Construction

Construction is unique but simple. The hub is a rugged steel cage whose side flanges are joined by 16 rods,

Fig. 9 Standard Kon-Toor refill wheel parts include the cage with its 16 elliptical tubes which engage the folded packets of coated abrasives; the correct size of bushing to fit the drive spindle; and the side plate. In use, the assembly is held in place by a conventional washer and nut. Canvas side shield reduces wind and noise.

each supporting an elliptical tube. These tubes hold U-shaped packets of folded, coated abrasive sheets with grain on both sides. Bushings are provided to fit standard drive spindles. Canvas side shields, which reduce wind and noise generated by the relatively open construction, complete the assembly.

Wheels are 17 in. in diam, and from 2 to 7 in. in width. For greater widths, wheels may be ganged. Performance is maintained unimpaired throughout the life of the wheel, and replacement wheels are available for ready mounting on the original cage or hub. Abrasive cloth used is Durite (silicon carbide) or Metalite (aluminum oxide) in a grit range from 120 to 400. Recommended wheel speeds range between 1500 and 2400 rpm, although variations in speed have less critical results than with conventional contact wheels or belts.

Designed for standard spindle mounting, the new wheel can instantly replace a setup wheel, wire-brush com-

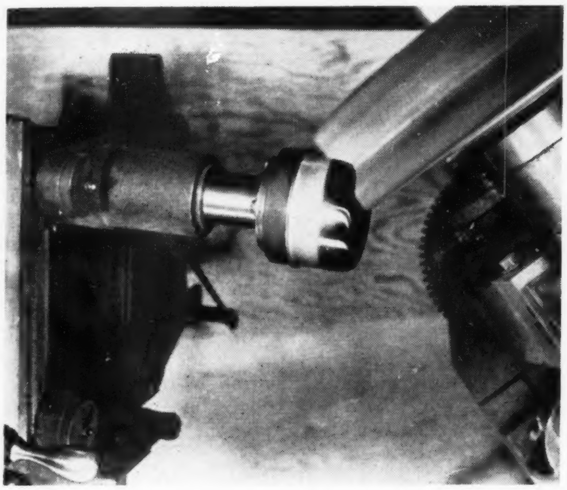


Fig. 10 Deeply contoured to match the profile of the piece, the wheel is mounted on a polishing head and the stainless-steel sauce pan being polished is rotated on a fixture against the wheel. Observe that this wheel is simultaneously polishing the base, the 90-deg contoured area, and a generous portion of the side.

pound wheel, or buffing wheel—without change of safety guards, backstands, or motor speeds.

Smooth Polishing Action

In use, the Kon-Toor wheel applies almost unbroken abrasive contact to the work, as opposed to the slapping action hitherto available in abrasive wheel designs. This smooth polishing action is a major reason for the superlative finishes which the wheel affords. Flexibility of the wheel as a whole is varied by using single or double-folded cloth.

Simple, slight contours may be polished with the wheel as delivered. To polish sharp angles or complex contours, the face of the wheel is dressed to the contour. Where the contour must be precise, a profile gage is used to transfer the contour of the workpiece to a wooden block; the block, faced with coarse sandpaper, is then used to dress the Kon-Toor wheel accurately.

The new wheel is fundamentally a polishing tool; as

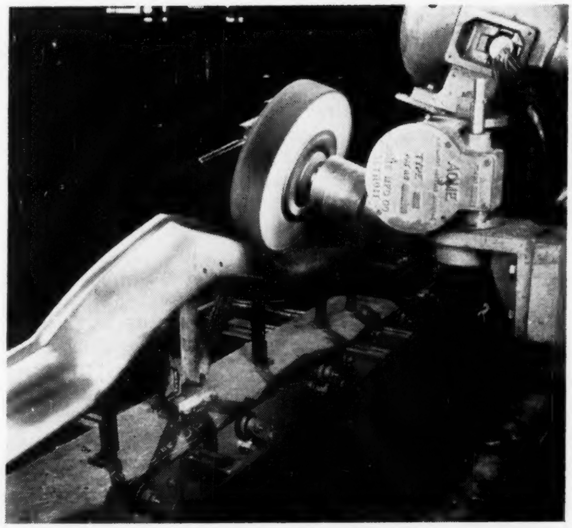


Fig. 11 Demonstrating how the Kon-Toor wheel is adaptable to polishing the most intricate equipment, it is shown mounted here on a full floating head, following the contours of a complete automobile bumper. The wheel can polish angular as well as curved surfaces of a part.

in the past, removal of weld marks and other major imperfections should be done by the usual coated-abrasive-belt method. In its own field, however, the Kon-Toor wheel has already performed in spectacular fashion —as in the plant where two wheels cover the entire contoured surface of a drawn-steel coffee pot, replacing a whole battery of polishing stations.

Spring Plant Expands

A $13,000,000 plant expansion and equipment modernization program carried out since the end of World War II—more than $4,500,000 of it devoted to the three Bristol divisions—has placed Associated Spring Corporation in an excellent position for continued growth in a highly competitive field, Carlyle F. Barnes, president of Associated Spring, told a group of technical press editors who visited Bristol, Conn., recently and inspected the operations of the three local divisions of the Corporation.

"We supply precision mechanical springs and other metal components to almost every industry—from automobiles and jet aircraft to television and textile machinery," Mr. Barnes said. "We have grown as industry in this country has grown. We started, nearly a hundred years ago, making wire hoops for crinoline skirts, and clock springs for the budding business of clock-making, which centered here in Bristol. Now we are making springs for guided missiles and atomic submarines—devices never even dreamed about a century ago. Yet these new requirements—and those still ahead of us, about which we can only guess at the moment—will utilize many of the same metalworking skills, gradually evolving over the years, which this company has developed and of which we are very proud."

These skills, Mr. Barnes pointed out, are backed up by the finest and most modern facilities in Associated Spring Corporation's 11 divisions located in the major industrial centers of the United States and Canada. The company

is also in excellent financial condition, he stated, citing the fact that the whole re-equipment and modernization program has been financed out of earnings and that the company has not had to borrow a dollar to pay for it.

All departments of the plants of the Bristol divisions, both in the center of Bristol and in Forestville, were inspected. Among the operations seen were the following: Automatic coiling of compression and extension springs, from very small to very large coils; high-speed automatic blanking presses, stamping out as many as 30,000 flat springs per hour, including the spring for the new Gillette razor-blade dispenser; multiple-slide forming of intricately-shaped locking springs and snap rings. These automatic multiple-slide machines exert forming pressure on wire stock in as many as seven different directions in all three dimensions; precision coiling of hairsprings for instruments, clocks, and delicate mechanisms, by the F. N. Manross & Sons division; making of TV tuner coils, essential component of television sets. Production, which has run as high as two-and-a-quarter million coils a month this year, is now completely going into color-TV sets; continuous cold-rolling of high-carbon steel, at the Forestville mill, where American workmen's mechanical aptitude and metallurgical skill turns out high-quality steel strip that can compete with and surpass the best Swedish or any other foreign steel according to the company; coiling of starter springs. These springs are used for starters made by the Eclipse Machine Division of Bendix Aviation Corp., and are used on all Ford Motor Company and Chrysler Corporation cars.

Passenger Conveyers

Moving Sidewalk

A MOVING sidewalk that can go around corners and carry passengers in two directions was unveiled recently by Hewitt-Robins, Inc., Stamford, Conn.

The new design solves various technical problems associated with earlier passenger conveyers and promises to clear the way to increased mechanization of pedestrian traffic at airports, large shopping centers, railroad terminals, and subways. It is designed to run at a speed of $1^2/_3$ mph, about average walking speed, but can be adjusted to run at faster or slower speeds if desired. Passengers in a hurry can walk while they ride and thereby double their rate of travel.

Three of the new conveyers will be installed in the new $10,000,000 air terminal to be built at Dallas Love Field, Dallas, Texas. They will carry passengers and their baggage from the ticket office to planes and bring incoming passengers from the planes into the terminal. The total length will be 1406 ft, more than twice the combined length of all other passenger conveyers currently in operation. The cost of the Dallas installation will be $234,703, and it is scheduled to be completed in 1957.

The new conveyer was demonstrated at the Hewitt-Robins plant in Passaic, N. J., where a 300-ft two-way conveyer is in operation.

Passengers stand on a rubber carpet fastened to a train of platforms, or pallets, mounted on rubber-tired wheels which run on a steel track. The rubber carpet stretches like a rubber band and is anchored to the pallets under tension. When going around a curve, the carpet stretches on the outside curve and contracts on the inside. It contains no reinforcing fabric such as is required on conventional passenger conveyers where a rubber belt pulls the load over a series of closely-spaced rollers. Patents have been applied for on this and several other features of the Hewitt-Robins conveyer.

The conveyer is driven by electric motors that transmit power to the pallets by means of a "caterpillar" type of chain which engages steel "dogs" on the underside of each pallet. The pallets are connected together by universal joints to form a continuous train. The carpet itself does not help to pull the load but functions entirely as a smooth, antiskid surface for the passengers to stand on.

The conveyer can run horizontally and over moderate grades up and down. It requires about 30 per cent less horsepower than other passenger conveyers and has fewer moving parts to lubricate and wear out.

One of its main advantages is its ability to carry passengers in two directions. This is possible because it can turn around and travel in a continuous circuit. Two-way travel on conventional conveyers could be achieved only by the installation of two separate conveyers at twice as much initial cost and cost of maintenance.

Fig. 12 Employees of Passaic, N. J., plant of Hewitt-Robins, Inc., take a ride on working model of new moving sidewalk developed by the company

Trav-O-Lator

Every phase involved in moving human beings has been considered in the design of the Otis "Trav-O-Lator,"—the easy and safe entry of the passenger, com-

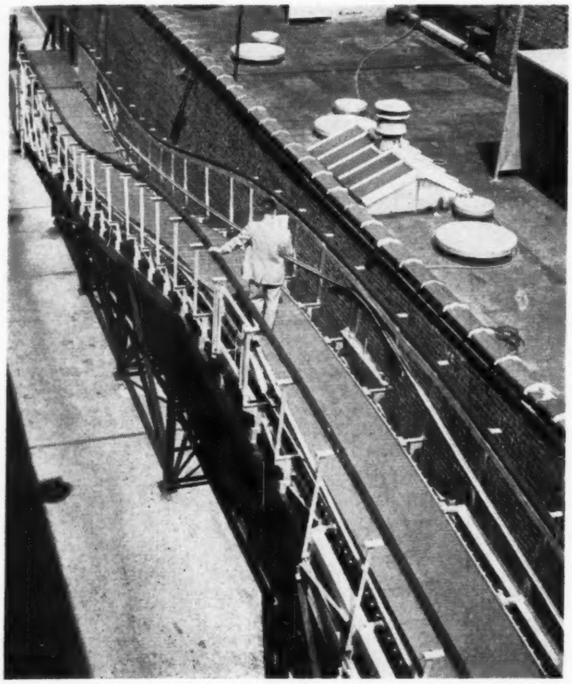


Fig. 13 This stripped-down prototype of Otis Elevator Company's Trav-O-Lator shows new application of the principles of the escalator to overland transportation. The device is designed to carry large crowds safely and comfortably for unlimited distances, horizontally or at an incline, at such places as airports, rail, subway, and bus stations, shopping centers, baseball parks, and other congested areas.

fort while riding, and safe exit. This new concept in human transportation adapting the tested principles of the escalator to overland travel by means of endless series of moving, metal-treaded platforms, was introduced at the Harrison, N. J., Works of the Otis Elevator Company.

The new device provides a fast, safe, comfortable method of moving large numbers of people in congested areas, such as airports; interconnecting subway, railroad, and bus stations; shopping centers; and sports arenas. Its applications are limitless and in the foreseeable future will be used to carry pedestrians over or under busy street intersections, be a means of removing many present restrictions on the spacing and location of groups of buildings, shopping centers, airports, and the like, imposed by considerations of human convenience. Thus it would free architects and engineers to create entirely new designs for such places.

The platform of the Trav-O-Lator is composed of a series of articulated, cleated treads, traveling on a wheel and track system, which affords a firm stable footing for passengers. The articulated platform rides on ball-bearing wheels.

It was revealed that installations of unlimited length can be made in series, with gradients of as much as 14 deg. While high speeds are theoretically possible, actual rates will be governed by the requirements of individual installations and human comfort. During the demonstration it was evident that actual passenger travel at speeds of 135 to 180 fpm are both practical and comfortable.

The Trav-O-Lator will be available in two widths. The 32-in. model will accommodate an adult and child side by side and will carry up to 7500 passengers an hour, while the 48-in. size will accommodate two adults side by side and carry up to 12,000 persons an hour; and by tandem arrangement will accommodate unlimited distances.

The problems associated with unsupervised transportation of people being radically different from those involved in the transportation of objects or materials, the use of cleated treads is a safety feature adopted by Otis for its Trav-O-Lator after long experimentation with other types of tread materials and design. This permits the use of a comb identical with that on a modern Otis escalator to allow passengers to make a safe, easy transition in getting on or off the moving treads.

Electronic Inventory Control

A COMPUTING machine or electronic "brain" to watch over 35,000 inventory items in the stockrooms of the Otis Elevator Company, is being built by Nuclear Development Associates, Inc. (NDA), White Plains, N. Y.

The Automatic Inventory Control System will cost over $200,000 to design, build, test, and install.

Otis officials estimate that it will save the company $120,000 annually in controlling the $10,000,000 inventory it carries to build and service elevators in its world-wide operations.

Because no two elevators are alike, Otis actually carries more than 70,000 separate inventory items. About half were eliminated from the automatic-control system for reasons of low cost, low turnover, or other factors which reduce their significance in the inventory operation.

According to NDA, the computing system would automatically carry out the following operations:

1 Keep a continuous up-to-date record of how much of each inventory item is on hand and how much on order, as well as the rate of use of the item over the past 15 months.

2 Warn the company when and in what quantities to reorder each of the 35,000 items and keep a record of open orders.

3 Provide a daily report for expediters on all items that are going on shortage and all contracts affected by these shortages.

4 Provide information for scheduling production to meet contract dates.

Otis production engineers established the formulas for obtaining the necessary information after an extended study of its inventory operation, and NDA designed and developed the computing machine to gather the data and compute the information.

In operation, a battery of 10 typists would feed about 20,000 items of information into the computing machine daily. During the night the machine will "digest" the information and feed the correct answers back into the typewriters where they would be available to the inventory managers at the start of the new working day.

In the initial typing, the information is punched on a tape similar to that used with teletype machines. From the punched tape, the information is fed onto a magnetic tape much like that used in an ordinary home recorder. The magnetic tape serves as the "memory" of the computing machine and also as the "scratch pad" for the

computation program. Nine tape mechanisms are employed, each containing a "head" which reads the information on the tape and transmits it to the various control and computing circuits by means of electrical impulses. These digest the data and produce the answers required for the next day's operation.

The output process is essentially the reverse of the input. The desired information is recorded on magnetic tapes and in turn transmitted to punched paper tapes. These are fed into the typewriters, and the information is automatically typed out. It is edited in this process to conform with the standard business form used in the typewriter.

A variety of controls were built into the system to avoid computation errors. It will automatically detect most computing errors in the system and repeat the step three times. If the error persists, the machine ceases operating. A periodic marginal testing system has been set up to subject the 2000 vacuum tubes and other sensitive points to conditions quite beyond those ordinarily encountered in operation in order to detect weak elements. This procedure greatly increases the reliability of the machine.

Brains by the Hour

International Business Machines Corporation demonstrated its new electronic data-processing center on the main floor of the company's headquarters in New York, N. Y.

The center contains an integrated team of so-called "giant brains," a complete lineup of high-speed digital computers and data-processing equipment. Included are IBM 702, 701, and 650 electronic data-processing machines as well as smaller, medium-sized electronic calculators.

This versatile combination of machines makes available on an hourly charge basis the latest tools for scientific management to companies which do not need full-time data-processing facilities of such capacity and speed and to companies whose own facilities are overloaded.

An outstanding feature of the exhibition was a series of demonstrations on the three largest machines. The 702 processed a day's activities on a 2500-item inventory in eight minutes. The 650 ran off part of a 2400-employee factory payroll, which in its entirety would take only three hours to complete, paychecks and department-cost accounting included. And the 701, running a mere ten minutes, solved a complex transportation problem to minimize costs for a company desiring to ship various quantities of a product from four origins to 51 destinations.

The center can handle all types of data-processing work. For example: For major business applications, there is the 702, the latest heavy-duty machine to be delivered by IBM. The basic hourly charge for the 702 in the center is $445.

Associated with the 702 is IBM's latest high-speed printer, which prints results calculated by the giant machine at the rate of 1000 lines a minute. At this rate it could record the equivalent of a 400-page novel in about four minutes.

For large-scale scientific and engineering calculations, there is the 702's technically minded running mate—the 701. It has been available on an hourly charge basis at IBM's headquarters in New York for over two years and, operating around the clock, has handled a variety of complex assignments for business, industry, and government. The predecessor to the 701 was the Selective Sequence Electronic Calculator, installed at the site of the new center in 1948. The SSEC was the first large commercial machine of its type to be made available to industry in this manner.

For either business or scientific work on a smaller scale, the center has a 650 magnetic drum machine. It is the first of its type to be shown publicly by IBM in New York City. The 650, a card-input, card-output machine, will now also be available as a tape-operated machine with a printer output.

Also in the processing center are smaller accounting machines, such as the 604 Electronic Calculator—costing $15 an hour—and other punch-card equipment. One of these machines is the IBM data transceiver which permits companies to make rapid use of the center's processing

Fig. 14 This is the IBM 702, the star attraction of IBM's new Data Processing Center at its New York City headquarters. The 702 was designed to process masses of business and industrial information and data such as is encountered in payroll production, inventory control, and all other areas of accounting.

facilities from remote points. Westinghouse Electric Corporation, in Pittsburgh, Pa., is currently using the center's 701 via Transceiver to solve engineering design and development problems.

The New York installation is the first of several to be opened at IBM offices in major cities. The purpose of these centers is to make electronic data processing available to more companies and institutions, particularly those which need only limited use of the biggest and fastest machines.

Glascast Process

A FAST economical method for the precision casting of metals through the use of glass molds has been developed by Corning Glass Works, Corning, N. Y.

The Corning Glascast process, designed especially for work with high-temperature alloys, is said to assure an excellent surface finish and the tight dimensional control required in precision casting. Because molds can be used at extremely high temperatures, design of fine detail and close regulation of metallurgical structure is possible.

In the test production of items such as jet-engine buckets and vanes, 90 per cent of the finished castings have met precision standards on surface finish. The Glascast process eliminates the use of the precoat step in investment casting and the undesirable cracking and spalling which necessitates rejecting a high percentage of the castings.

Easy to use, Corning Glascast powder is essentially a 96 per cent pure silica glass which is mixed with water to produce a casting slip. Poured into a porous-plaster form, the slip builds up into a Glascast shell which is dried, removed from the plaster, and fired. The mold is then ready for use without further treatment.

Castings produced by the Glascast process have blemish-free surfaces of better than 40-microinch finish requiring little or no further conditioning. The mold material has high chemical stability and does not react with the metal or its oxides to cause surface imperfections. Accurate control of grain size is thus possible even at metal-pouring temperatures as high as 3200 F.

Close dimensional control is assured because the vitreous Glascast powder has extremely low thermal expansion, avoiding the abrupt volumetric changes typical of foundry sands. Tolerances of 0.005 in. per in. can be obtained readily.

Glascast has excellent resistance to thermal shock and molds can be fired without danger of cracking (hot shells will not crack even when held under a stream of cold water). Definition may be held to 0.020 in. and the very low mold expansion enables accurate calculation of metal shrinkage.

Low tool-up costs make short runs possible and shop hold-up time from mold preparation to actual casting is greatly reduced. The new technique is suitable for any of the conventional casting methods (static, pressure, centrifugal, vacuum) used in working with metals such as aluminum, brass, carbon steels, stainless steels, cobalt base alloys, and chromium base alloys.

Fabrication of Glascast molds requires a minimum of equipment and material. Standard equipment includes a model, containers for slurry, scales, a mechanical mixer, drying oven with temperature control between 105 and 300 F, and a firing furnace with temperature range up to 2000 F. Materials consist of Glascast powder, dense

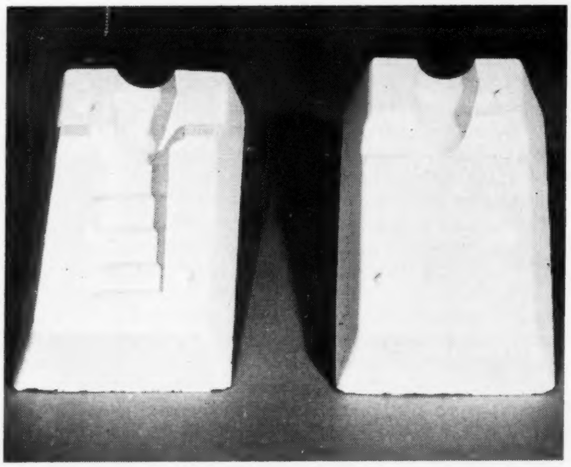


Fig. 15 Two completed Corning Glascast mold halves

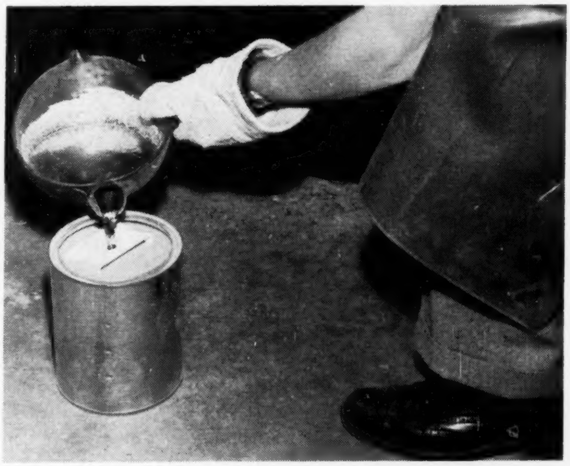


Fig. 16 Pouring the casting metal into the Glascast mold

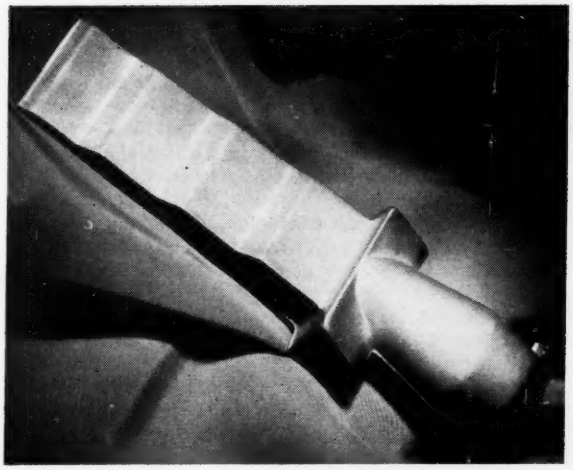


Fig. 17 Finished casting removed from the Glascast mold

plaster, porous plaster, parting compound, and water.

The model of the desired casting may be any machinable material which can be given a high finish and will meet dimensional requirements. The model is embedded in a profile plate incorporating the desired gating, risering, and parting line. Parting compound is applied and dense plaster slurry is poured into the mold box and allowed to set.

From this pattern, working porous-plaster molds are formed. A parting compound of Bayberry wax and gasoline mixture is recommended for application to the pattern. The porous-plaster mold is poured, allowed to set, and dried between 125 F and 140 F to avoid calcination and cracking. The finished plaster mold will make from 15 to 20 Glascast shells before surface and dimensional deterioration.

Slip for the Glascast mold is then prepared by measuring four parts by weight of Glascast powder with one part of water. A 10-lb batch can be mixed with a high-speed mixer in an hour by feeding the powder into the water gradually, or the slurry can be mixed in stoppered bottles on rollers. The slip will last indefinitely as long as it is agitated constantly.

Glascast slip is poured into the porous-plaster mold and allowed to stand from 5 to 10 min until enough water has been absorbed to build up a shell of glass solids to the desired thickness. Excess liquid slip is drained off for re-use and the glass shell is dried for 15 min at 140 F. After removal from the plaster form, the Glascast shell is oven-dried at 200 F and then fired for $^1/_2$ hr between 1740 and 1920 F, depending on the strength desired. The Glascast mold is then ready for immediate casting or for storage.

In the actual casting process, the shell assembly can be wired or taped together and backed by loose sand, metal shot, or any granular refractory material. Or it may be held in place with wire or refractory cement. The mold is preheated to the desired temperature for 10 min and is then ready for casting.

Under development for the past three years, the Glascast process has been tested successfully in commercial-production situations. Assistance in the program has been given by the Massachusetts Institute of Technology, the Engineered Precision Casting Company, and others.

World Atomic-Energy Survey

According to an international survey of atomic-energy development, there are currently 42 nuclear reactors known to exist in the world.

The survey, which took a year to complete and is entitled "World Development of Atomic Energy," was conducted by the Atomic Industrial Forum, Inc., and covers 32 nations which have officially reported, or are known to have, substantial atomic-energy activity.

Of the known reactors of the world, many of which were described at the United Nations Conference on the Peaceful Uses of Atomic Energy (in Geneva, Switzerland, August 8-20, 1955), 29 are located in the United States, 5 in Great Britain, 2 in France, 2 in Canada, 1 in Norway, 1 in the Soviet Union, 1 in Sweden, and 1 in Switzerland. The last-named is the swimming-pool reactor built by the United States on the grounds of the Palais des Nations in Geneva as an exhibit at the United Nations atomic-energy conference.

In addition, the survey shows that 20 reactors are currently known to be under construction: 9 in the U. S., 3 in Great Britain, 3 in France, and 1 each in Australia, Belgium, Canada, India, and the Soviet.

It is generally assumed that additional reactors are in existence and under construction in the Soviet, but the Soviet government has not announced them. Of the nations of the world known to have atomic-energy programs involving the operation or construction of nuclear reactors, only the Soviet Union failed to respond to the Forum survey.

In the planned-for-construction category, Great Britain leads the world with 22, the U. S. is second with 16, and other nations follow in this order: France 3; Belgium, 1; Canada, 1; Italy, 1; the Netherlands, 1; Sweden, 1; Switzerland, 1; and West Germany, 1. In addition, there are 23 nations (as of July 28) which may now build small research reactors under bilateral "agreements for co-operation" with the U. S.

The survey reports on 17 nations known or believed to possess workable deposits of uranium, and on 4 nations known to possess thorium.

The survey also cites the available information on the organization and principal personnel of the atomic-energy programs in the countries covered, their principal laboratories and research centers, the major physical research equipment they possess, their activities in the utilization of radioisotopes, their international arrangements for co-operation, and their objectives and plans for the future.

Also included in the survey is a list of titles of the more than 1000 papers included in the proceedings of the United Nations Conference on Peaceful Uses of Atomic Energy.

Copies of the report are on sale at the Forum's offices, 260 Madison Ave., New York 16, N. Y., for $5 per copy.

Atomic Medical Reactor

The first atomic-energy reactor specifically designed for medical treatment and research will be built for the University of California at Los Angeles Medical Center by North American Aviation's Nuclear Engineering and Manufacturing Division.

According to the announcement, the new reactor will produce gamma rays and neutrons for cancer therapy and also has been designed to serve a variety of additional medical and nonmedical uses. These include the production of radioisotopes and radiation for experimental sterlization and preservation of food and drugs by nuclear energy.

The reactor, which is expected to be completed within one year, also will be available for use by the Atomic Energy Commission in conjunction with the Atomic Energy Project at UCLA, where both classified and unclassified research in biology and medicine is caried on.

Designed to operate at a power level of 5 kw, with a maximum power of 50 kw, the medical reactor will produce a high intensity of neutrons, subatomic particles available only from a nuclear reactor in the large amounts required for medical therapy and other atomic research. Gamma rays produced by the reactor will be of greater intensity than those produced by 50 lb of radium.

The reactor's atomic fuel is to be obtained on loan from the AEC and will consist of about four gallons of

uranyl sulphate solution, highly enriched in Uranium 235, contained in a one-foot stainless-steel sphere, or core.

It is the "splitting up" or fissioning of the Uranium 235 atoms in the solution which provides the gamma rays and neutrons for medical treatment and other nuclear research. The core will be located inside a 5 × 5 × 8-ft stack of graphite bars, shielded by five feet of high-density concrete. Radiation ports will lead from the core to a patient treatment room, laboratory, and another room where research on animals can be performed. An access port will permit materials to be irradiated in a channel leading inside the core itself where radiation will be the strongest.

The underground reactor wing housing the complete installation will be about 45 ft wide, 60 ft long, and 27 ft high.

Rate of fission will be adjusted by control rods made of boron which can be moved in or out of the core area. Boron absorbs neutrons; thus when the rods are near the core neutrons are "soaked up." As the Uranium 235 atoms are split when hit by neutrons, fission will stop when the neutrons are caught by the boron rods.

The solution-type reactor will be self-contained, with no radioactive particles, fumes, or smoke being exhausted into the atmosphere or public disposal systems.

Either gamma rays or neutrons can be obtained from the reactor for cancer treatment. While both are radiated from the reactor during the fission process, gamma rays or neutrons can be selected by use of special shielding equipment between the patient's room and the reactor core. The size of the radiation port also can be varied to provide radiation in the required amounts or intensities.

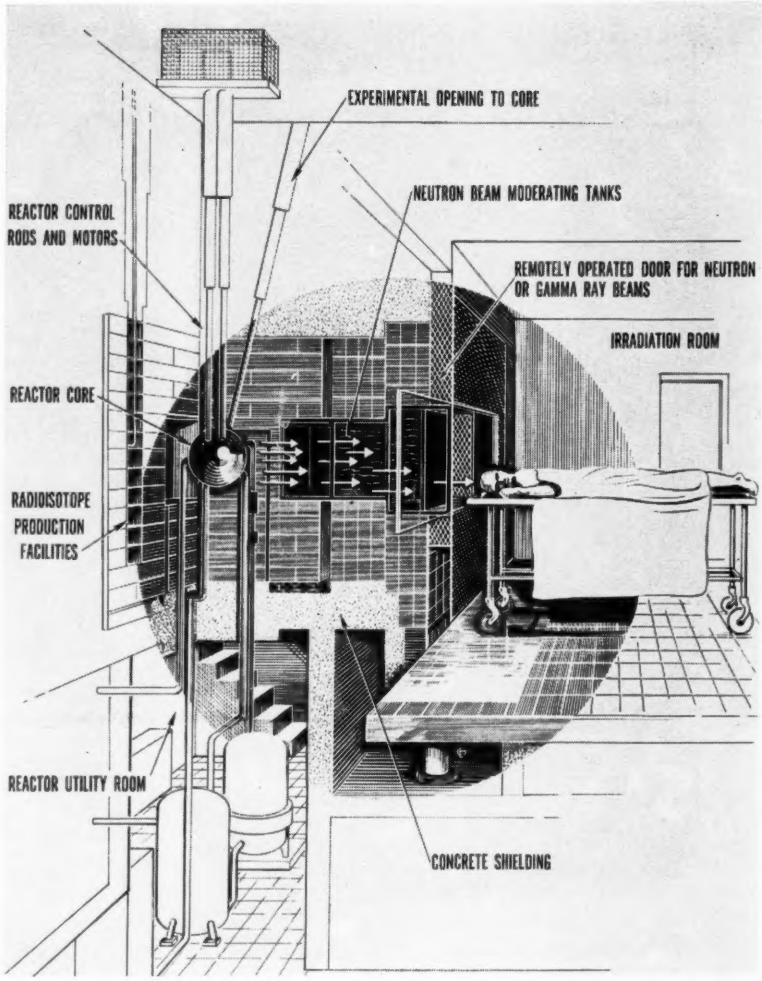


Fig. 18 Artist's sketch of the first atomic-energy reactor specifically designed for medical therapy and research which will be built for the Medical Center at the University of California at Los Angeles by North American Aviation's Nuclear Engineering and Manufacturing Division. Producing gamma rays and neutrons from atomic fission, the reactor will be located in an underground wing of the University's new medical school. The 50-kw reactor will also be used to produce radioisotopes and radiations for studies in the preservation and sterilization of food and drugs.

Gamma rays destroy cancer cells much in the same way as is done by x rays, but the gamma rays penetrate deeper through tissue and are much stronger than x rays.

Irradiation of cancer cells with neutrons is often accomplished by the "boron-capture" technique. This requires the injection into a tumor of a solution containing the element boron. Due to the particular nature of the cancer cell, the cancerous tissue absorbs the boron much more quickly and in greater amounts than does healthy tissue. When the cancer area is bombarded by a stream of neutrons, the boron atoms in the cancer cells release "alpha particles." These particles which are tiny masses carrying an electrical charge, and weigh about four times as much as a neutron, are effective cancer-cell killers. Alpha particles have a short penetration range, primarily confining their destruction to cancer cells and doing relatively little harm to healthy tissue.

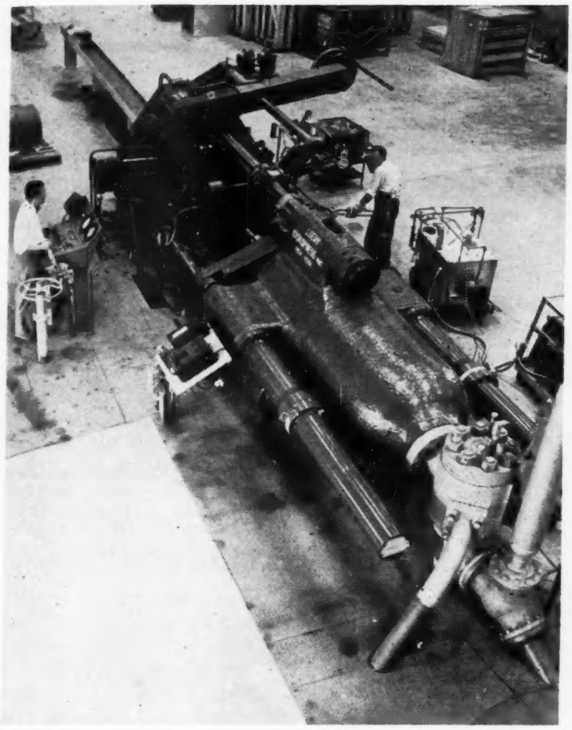
The experimental use of radiation from nuclear reactors to preserve and sterilize foods and drugs is a promising field which is expected to lead to revolutionary processing methods. Research in this field has already demonstrated the possibility of increasing the "fresh" life of meat, vegetables, and dairy products by atomic radiation. Use of radiation sterilization in the pharmaceutical field also offers a number of benefits. For example, sterilization processing requiring high temperatures which often reduce the strength and effectiveness of drugs might be replaced by radiation processing at room temperature. Nuclear researchers at UCLA have scheduled time with the reactor for this type of development work in addition to other studies.

Metals and Ceramics Building...

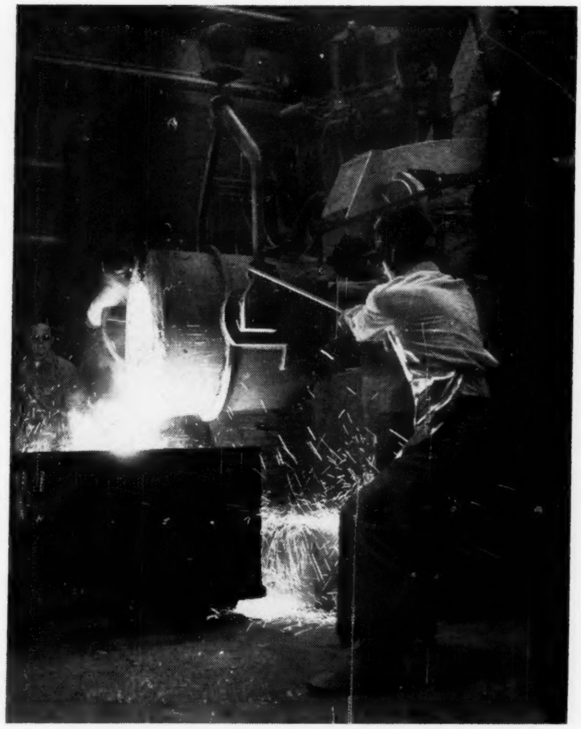
...dedicated at General Electric Research Laboratory

Erector-Set Construction. The "pilot-plant" feature of the new Metals and Ceramics Building at the General Electric Research Laboratory near Schenectady, N. Y., requires that structural members be assembled quickly and altered as the process is developed and perfected. This requirement is met by utilizing full-size "erector-set" structural members where needed in the building. Engineers are examining one of the adjustable corner columns. Dedicated on August 26, 1955, the huge new laboratory's objectives are: (1) To ascertain and analyze the areas of most critical need for materials and processes; (2) to develop new processes for new businesses; (3) to develop new materials to improve products; (4) to study existing materials and obtain a better understanding of their properties and processing; and (5) to operate pilot plants and obtain economic data. At first glance, the new building (see frontispiece, page 760)—which measures 312 × 160 ft and has more than 75,000 sq ft of floor space—seems more like a factory than a laboratory. However, there is an obvious difference between this facility and a factory. Here the standard equipment as well as the special equipment is operated under laboratory conditions, with emphasis on measurement and control, and freedom from production schedules.

Ceramics Furnace Area. Shown here is an over-all view of the ceramics furnace area in the new Metals and Ceramics Building. This equipment is used in sintering and melting ceramics at high temperatures. Facilities for the study of ceramics have been placed side-by-side with those for metallurgy because of (1) the tremendous importance of ceramic materials in the electrical industry for insulators, lamps, radio and television equipment, and other applications; and (2) the fact that metallurgy and ceramics are closely allied fields since both metals and ceramics are crystalline solids and the laws governing their behavior are identical.

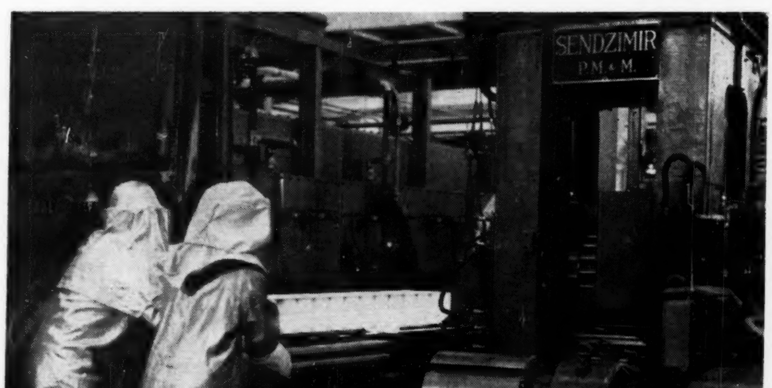


1250-Ton Extrusion Press. The 1250-ton extrusion press operating in the building ranks among the country's fastest in extrusion rate. In addition to the austenitic "superalloys" already being used in aircraft gas-turbine blades, the press can extrude the experimental refractories such as tungsten, molybdenum, and chromium alloys. Most of these metals are extremely brittle as-cast and must be deformed by extrusion before they can withstand further working.



Three-Phase Arc-Melting Furnace. Metal is poured into a sand mold from the ladle of the three-phase arc-melting furnace installed in G-E's new research facility. The furnace—large for a research facility—can melt a wide variety of alloys in one-ton heats for process and application studies. The melting operation is large enough to provide information that is directly transferable in solving problems encountered in commercial foundries.

Planetary Mill. The planetary mill installed in the new building utilizes an entirely new system of rolls in the hot reduction of metals. The "sun-and-planet" arrangement of rolls (showing between the columns) permits reduction as great as 20 to 1, about ten times that produced by conventional rolling mills.



European Survey

Engineering Progress in the British Isles and Western Europe

J. Foster Petree,[1] *European Correspondent*

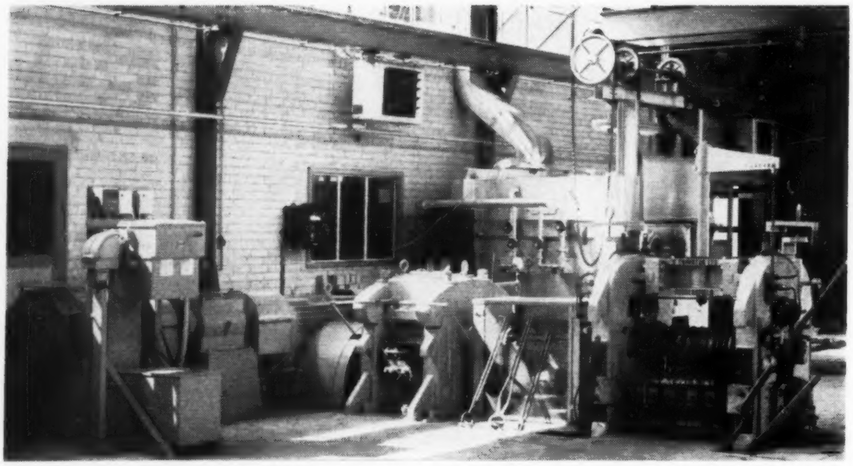


Fig. 1 The 11-in. 3-high experimental hot-rolling mill at the Swinden Laboratories. The gas-fired muffle furnace can be seen immediately behind the mill.

Experimental Hot-Rolling Mill

The Research and Development Department of the United Steel Companies, Limited, which produce about $12^1/_2$ per cent of Britain's steel output and have their headquarters at Sheffield, England, has recently installed in the Swinden Laboratories of the organization at Rotherham a three-high experimental hot-rolling mill.

Its main purpose is to roll ingots into bars (with a single set of rolls) for metallurgical and mechanical research in the development of new alloy and other steels, but it will be used also for investigations into the manipulation of steel by rolling—for example, in roll pass design—and as a test rig for mill auxiliaries and for the investigation of problems that may arise in production mills. It was constructed by B. Thornton, Limited, of Huddersfield, and has rolls 11 in. in diam and 38 in. wide; and is driven by a 100-hp alternating-current motor, made by the Metropolitan-Vickers Electrical Company. The drive is through a David Brown four-speed gearbox and a worm reduction gear. The motor runs at 750 rpm and the rolling speed ranges from 50 to 250 fpm.

The present equipment of rolls will reduce ingots

[1] Correspondence with Mr. Petree should be addressed to 36 Mayfield Road, Sutton, Surrey, England.

Fig. 2 Three high-frequency furnaces for experimental steelmaking at the Swinden Laboratories. They can produce ingots (from *left to right*) of 5 lb, 25 lb, and 112 lb weight, respectively. The cabinet behind the furnaces contains a bank of capacitors and other electrical gear.

$2^7/_8$ in. square to rounds of $^3/_4$ in. or $1^1/_8$ in. diam, with various intermediate square sections, but further sets of rolls are to be provided for rolling ingots $4^5/_8$ in. square down to billets $2^7/_8$ in. square or to flats $^1/_2$ in. thick. Instruments are fitted for measuring the roll-separating forces, the spindle torque, and the rolling temperatures. Rolling finished rounds from the ingot with one set of rolls is not normal practice, but it has been found possible to produce bars, in various qualities of steel, of a sufficiently high standard for machining into test specimens.

In the same building as the mill are three new electric furnaces to melt the steel for the ingots. These are high-frequency units made by the Electric Furnace Company, Weybridge, Surrey, England, and are capable of making experimental ingots of 5 lb, 25 lb, and 112 lb weight, respectively. The furnaces take their current from a motor alternator with an output of 50 kw at 9900 cycles, single phase, driven by a motor of 96 hp running at 3000 rpm and supplied with three-phase 50-cycle current at 415 volts.

Peaceful Uses of Atomic Energy

By the time that this "Survey" appears in print, the first International Conference on the Peaceful Uses of Atomic Energy will have concluded its deliberations at Geneva, and there is little doubt that a foundation will have been laid, not merely for the holding of further international conferences—it is unthinkable that the first will prove to be the only one—but for measures of practical collaboration between nations and between individual scientists of almost limitless potentialities for human good.

For the record, it may be recalled that the initiative was taken in December, 1954, when, by a unanimous vote, the General Assembly of the United Nations decided that such a conference should be held to study "the development of atomic power" and to "consider other technical areas—such as biology, medicine, radiation, protection, and fundamental science—in which international co-operation might most effectively be accomplished."

Following a preliminary meeting of the Advisory Council with the Secretary-General, Mr. Dag Hammarskjold, in New York in January, 1955, invitations to participate were sent to the 60 nations which are members of the United Nations and also to 24 which are not.

Dr. Homi J. Bhabha, the chairman of the Atomic Energy Commission of India, was appointed President of the Conference, and Professor Walter G. Whitman of the Massachusetts Institute of Technology, as Conference Secretary-General. It was announced that all sessions would be open to the public, with simultaneous interpretation in English, French, Russian, and Spanish.

The advance agenda showed that the papers, numbering over 1000, would cover so wide a field that no attempt will be made here to describe the scope of the Conference in detail; but it was clear that the significant divisions, as a start, were likely to be "The Need for a New Power Source," associated with a survey of the sources of power already available and the power requirements of individual countries; "The Role of Nuclear Energy" and the practical economics of realizing it; "Health and Safety Aspects of Nuclear Energy"; "The Production and Use of Isotopes"; "Problems Relating to Large Quantities of Radioactive Substances"; technical and design problems, and "Problems of Waste Treatment and Disposal"; "Tracers in General Research"; and "Industrial Utilisation of Fission Products."

The final plenary session, it was stated, would be devoted to an endeavor to summarize the conclusions, with special reference to the training of technical personnel for work on, and with, nuclear energy, and means whereby the nations which have pioneered the development of the techniques can best assist other nations to apply atomic energy to peaceful purposes.

The response to the invitations to participate was world-wide and the indications are, at the time of writing, that, in prospect, the interest aroused by the Conference even transcends that in the "summit" conference at Geneva between the heads of the "Big Four" Governments on which President Eisenhower reported in a nation-wide (in effect, a world-wide) broadcast on July 25.

The Automatic Factory

The conference on "The Automatic Factory—What Does It Mean?" which the Institution of Production Engineers held at Margate, England, in June, packed into its three plenary sessions, four discussion sessions, and a session of group reports such a variety of topics and aspects of the subject that to summarize it is almost as difficult as reporting the Atomic Energy Conference promises to be. It was well attended—not many British conferences on engineering matters muster more than 1000 members—and the discussions were lively, even though some of them went on until 11 p.m., but the fact was that the scope of the program would have given ample occupation to perhaps three or four such conferences.

Sir Walter Puckey, the President of the Institute, in an opening address entitled "The Automatic Factory—Dream or Nightmare?" tried to put automation into a true perspective by pointing out that it was only a logical development of mechanization, which would make further mechanization more effective by enhancing control power over the machine.

Automation, Sir Walter said in his address, was a tool which could be very widely applied and should accelerate the rate at which industry could absorb new ideas. This might cause temporary dislocations affecting a large percentage of the working force, but, far from displacing labor, it must ultimately demand more skills and afford more opportunities. He thought it doubtful, however, on present evidence, whether enough basic power would be available to support a full program of automation. In general, he agreed with Walter Reuther, president of the C.I.O., that there was no reason why everyone should not benefit from the Second Industrial Revolution; which, in Sir Walter's opinion, was no new manifestation, but "started a few decades ago, when a sufficient number of people realized that, in developing the machine, we had forgotten the man."

But so far, he asserted, "the automatic factory does not exist, and to suggest that many of these units are just around the corner is misleading and dangerous."

ASME Technical Digest

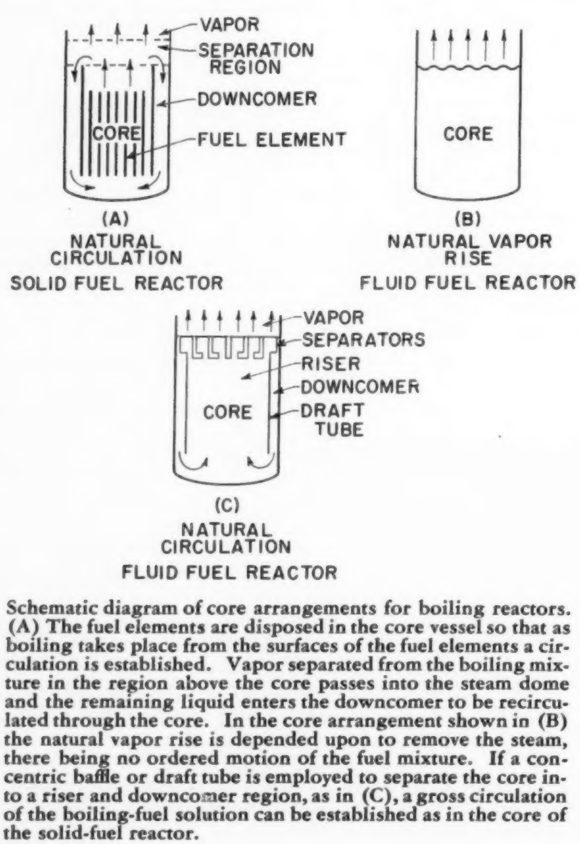
Substance in Brief of Papers Presented at ASME Meetings

Nuclear Engineering

Power Removal From Boiling Nuclear Reactors, by P. C. Zmola, Assoc. Mem. ASME, and R. V. Bailey, Oak Ridge National Laboratory, Oak Ridge, Tenn. 1955 ASME Semi-Annual Meeting paper No. **55—SA-80** (multilithographed; to be published in Trans. ASME; available to April 1, 1956).

PRINCIPAL features of a nuclear reactor from which power is removed by boiling of the coolant within the active core are discussed. For most applications the coolant is also the moderator and possibly the fuel carrier, and the objective is to devise a core arrangement which will permit operation at the highest power density for a given average fluid density.

Calculations based on simple theoretical models are presented in performance-chart form to display the relation of influencing variables. Experimental results obtained from systems in which boiling was produced by electrical resistance heating of the liquid or simulated by bubbling air through the apparatus are summarized. A method for calculating the density distribution in a boiling system which takes into consideration explicitly the relative velocity of the vapor and liquid is presented.



Schematic diagram of core arrangements for boiling reactors. (A) The fuel elements are disposed in the core vessel so that as boiling takes place from the surfaces of the fuel elements a circulation is established. Vapor separated from the boiling mixture in the region above the core passes into the steam dome and the remaining liquid enters the downcomer to be recirculated through the core. In the core arrangement shown in (B) the natural vapor rise is depended upon to remove the steam, there being no ordered motion of the fuel mixture. If a concentric baffle or draft tube is employed to separate the core into a riser and downcomer region, as in (C), a gross circulation of the boiling-fuel solution can be established as in the core of the solid-fuel reactor.

Engineering Problems of Power Reactors, by Harry J. Bolwell, Combustion Engineering, Inc., New York, N. Y. 1955 ASME Semi-Annual Meeting paper No. **55—SA-77** (multilithographed; available to April 1, 1956).

THIS paper illustrates some of the problems facing those who design and build nuclear-power reactor systems. In considering these problems the paper is limited to heterogeneous reactors cooled by either water or liquid metal.

The first factor to consider is the primary coolant and its effect on the equipment design. The following requirements are common to all reactor coolants:

1 The coolant must be a good heat-transfer medium;
2 The coolant must be amenable to maintaining high purity;
3 The coolant must cause little or no corrosion of the fuel elements or primary system equipment;
4 The coolant must be contained. A high degree of leak tightness is a requirement of any reactor system.

Fuel elements used in an aqueous system must be clad with a noncorroding material. If an unclad uranium fuel element were used in a water system, the corrosion of the uranium would be measured by the yard. The corrosion problem when sodium contacts uranium is not as serious. In future reactor designs, fuel-element cladding may not be required with a sodium coolant. The necessity of cladding the aqueous-system fuel elements imposes a fabrication problem on the reactor designer and builder. The materials to be clad, such as uranium and plutonium, as well as certain cladding materials, such as zirconium, are relatively new materials, and a backlog of fabrication experience is not available.

In addition to fuel elements a typical reactor core would contain the following components:

1 Flow guides to insure an equal flow distribution throughout the core;
2 Control rods to control the reactor;
3 Bearings for these rods as they move;
4 A thermal shield to alleviate thermal stress in the reactor vessel; and
5 A hold-down device to prevent the fuel elements from moving or chattering under high flow conditions.

All of these components must be fab-

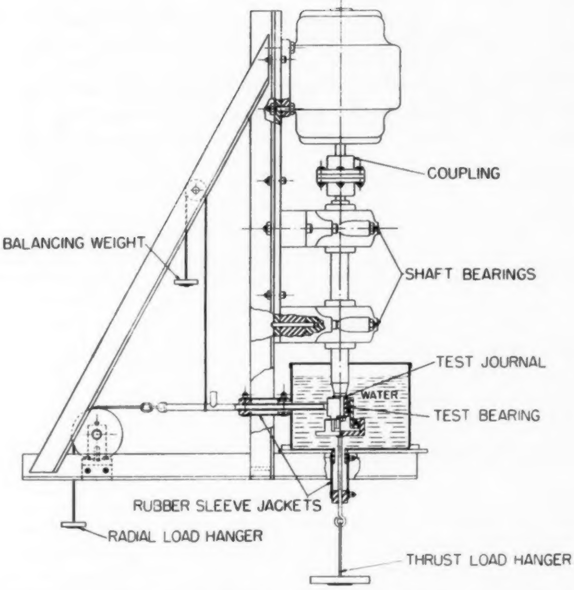
ricated from a special noncorrosive material. Since physical positioning must be maintained with extreme accuracy in a reactor core, all the components must be fabricated to close tolerances. The rod bearings cannot be lubricated and yet the rods must have complete freedom of motion. The hold-down device must be capable of giving core rigidity and yet must be a quick opening device for ease of core reloading. These problems are typical in that they are relatively complex and interrelated.

Fast-Reactor Accident Dynamics, by Robert Daane, Nuclear Development Associates, Inc., White Plains, N. Y. 1955 ASME Semi-Annual Meeting paper No. **55—SA-74** (multilithographed; available to April 1, 1956).

The self-limitation of an accidental power excursion by thermal expansion of the fuel in a fast reactor with core-length metallic rod-type fuel elements is analyzed.

Approximate formulas are presented for the peak power, temperature rise, and stress induced in the fuel rods, taking into account the inertia effects.

Water-Lubricated Bearing Studies, by A. Smaardyk, Argonne National Laboratory, Lemont, Ill. 1955 ASME Semi-Annual Meeting paper No. **55—SA-42** (multilithographed; available to April 1, 1956).



Test apparatus for evaluation of water-lubricated bearings. The bearings were run on a vertical shaft and tested at speed from 50 to 3600 rpm under radial and thrust load. The loads were applied simply by suspended weights acting on the outer-bearing holder. Bearings up to 1 1/2 in. diam × 2 in. long immersed in a pan filled with distilled water were tested at varying conditions of load and speed.

Research at Argonne National Laboratory is directed toward the development of water-cooled nuclear-power reactors. One of the problems in connection with the water-cooled reactor systems has been to find suitable bearings for various component mechanisms operating within the highly purified water at temperatures up to 500 F without the benefit of additional lubrication.

Development work has been conducted on various bearing designs such as pivot, journal, and rolling-contact types, including an evaluation of various components subjected to continuous rubbing or metal-to-metal contact.

Application of water-lubricated bearings and rubbing contact surfaces in nuclear reactors posed design criteria which differ radically from conventional bearing design criteria normal to conventional power plants. They are: Utmost reliability, operating conditions, leakage restrictions, cleanliness, effects of irradiation.

Various types of bearings that have been evaluated can be grouped according to the type of frequency of operation, namely: (1) Continuously rotating bearings such as encountered in the coolant pumps external to the reactor vessel; (2) intermittently sliding, rotating, or oscillating bearings such as encountered in the operation of control rods and the associated mechanisms, which are usually located within the reactor vessel; (3) occasional sliding or rotating components located in the water circuit external to the reactor vessel (for example, valve mechanisms).

Water-lubricated bearings are divided further into two distinct groups: (1) Sliding-contact bearings, (2) rolling-contact bearings.

In general, the load-carrying capacity of a bearing operating in high-purity water is only a few per cent of a similar oil-lubricated bearing.

Highest load-carrying capacity is exhibited by a fluid-film water-lubricated bearing; however, this type of bearing is limited to low-temperature application.

The rolling-contact bearing and metal sliding-contact bearings are suitable for operation in high-temperature water, provided the materials used possess corrosion and wear-resistant properties that meet the required design criteria.

Types of ball bearing giving best performance are in the order of preference: (1) Double-land-riding micarta retainer, although the desirability of this material decreases for temperatures in excess of 200 F; (2) bearing with spacer balls; (3) bearing with a full complement of balls.

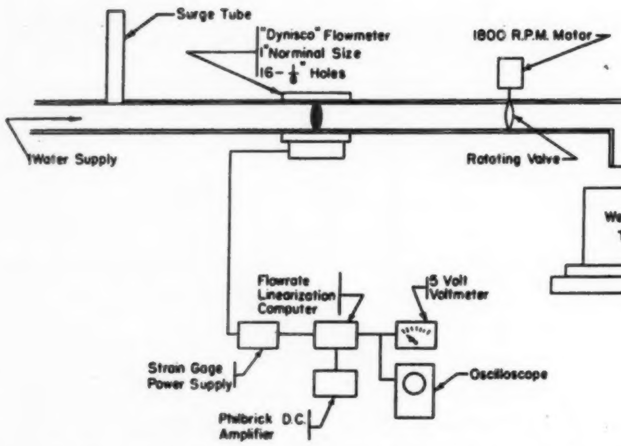
Fluid Meters

New Schemes for Pulsating-Flow Measurement With Head-Type Meters, by Yao Tzu Li, Massachusetts Institute of Technology, Cambridge, Mass. 1955 ASME Semi-Annual Meeting paper No. **55—SA-79** (multilithographed; available to April 1, 1956).

Dynamic errors of an ordinary head-type flowmeter under pulsating-flow conditions are the results of the inadequate dynamic performance of the differential-pressure gage used, plus the undesirable effects of the "virtual mass" of the flow-sensing element. Physical aspects of the virtual mass of several types of flow-sensing element configurations are studied in this paper. Schemes for the reduction of the virtual mass of the flow-sensing elements are discussed.

A high-frequency perforated vane-type flowmeter and a high-speed linearization computer (adjustable square rooter) are described.

Experimental results with the strain-gage perforated vane-type flowmeter and the electronic linearization computer



Schematic diagram showing apparatus for pulsating-flow measurement test setup

demonstrated the capability of accurately measuring a 100 per cent pulsating flow at 30 to 150 cps. The flowmeter was designed for handling corrosive fluid at 2000-psi line pressure with a one-inch pipe. It has a natural frequency of 2000-cps and is balanced to be non-sensitive to axial vibration.

The computer-amplifier has a remarkable stability to zero drift and to change sensitivities. As an electronic instrument it is considered simple and is very flexible for flowmeter purposes. The complete system can be packaged into a 6 in. × 6 in. × 8 in. box including the meter.

Machine Design

Determination of Pressure Angles for Swinging-Follower Cam Systems, by Martin Kloomok, International Business Machines Corporation, Endicott, N. Y., and R. V. Muffley, Assoc. Mem. ASME, International Business Machines Corporation, San Jose, Calif. 1955 ASME Semi-Annual Meeting paper No. **55—SA-38** (multilithographed; to be published in Trans. ASME; available to April 1, 1956).

Of the several factors that determine the success of a cam system, one of the most important is pressure angle. Too high a pressure angle will cause high surface compressive loadings between follower and cam, and the cam shaft-drive torque will be considerably increased. Accordingly, the designer should know the maximum value of pressure angle in any new cam system.

In the past, pressure angle has been determined largely by using a protractor on a layout of the cam. This practice becomes very time-consuming, however, when it is necessary to make a series of layouts to arrive at optimum proportions. Advance calculation is to be preferred if it can be kept simple.

In this paper, an exact expression is derived for pressure angle in a swinging roller-follower cam system, and a chart is presented indicating a method for finding a quick numerical solution for a particular cam contour, such as the harmonic or the cycloidal.

Hydraulics

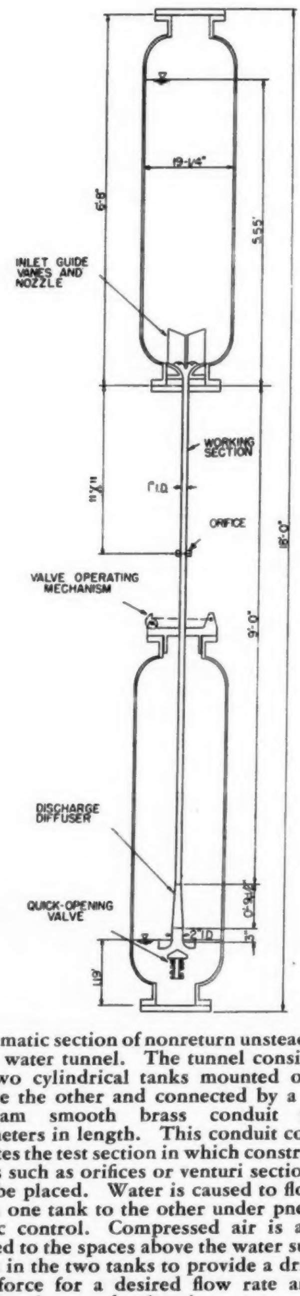
Resistance Coefficients for Accelerated and Decelerated Flows Through Smooth Tubes and Orifices, by J. W. Daily, Mem. ASME, and J. M. Jordaan, Jr., Massachusetts Institute of Technology, Cambridge, Mass., W. L. Hankey, Jr., Wright Patterson Air Force Base, Ohio, and R. W. Olive, Mem. ASME, General Electric Company, Lynn, Mass. 1955 ASME Semi-Annual Meeting paper No. **55—SA-78** (multilithographed; available to April 1, 1956).

This paper summarizes the results of investigations in the Massachusetts Institute of Technology unsteady-flow water tunnel of accelerated and decelerated flow through uniform conduits and orifices in conduits. In the uniform conduit shear and turbulence are generated through boundary-layer friction and are essentially uniform along the duct. The orifices cause separation and jet formation with accompanying high shear and turbulence which vary along the duct as the jet diffuses and the turbulence is dissipated.

It it concluded that the imposition of an unsteady transient produces different effects for the two basic types of flow investigated, as follows:

1 For cases of surface resistance caused by boundary shear stresses: (*a*) With acceleration the resistance is slightly but not appreciably greater than for the equivalent steady state; (*b*) With deceleration the resistance is appreciably less than for the equivalent steady state; (*c*) With either acceleration or deceleration, it appears that the internal flow structure is not markedly different from that for steady states.

2 For cases of form-type resistance associated with the high shear and gen-



Schematic section of nonreturn unsteady-flow water tunnel. The tunnel consists of two cylindrical tanks mounted one above the other and connected by a 1-in-diam smooth brass conduit 99 diameters in length. This conduit constitutes the test section in which constrictions such as orifices or venturi sections can be placed. Water is caused to flow from one tank to the other under pneumatic control. Compressed air is admitted to the spaces above the water surfaces in the two tanks to provide a driving force for a desired flow rate and acceleration or deceleration.

eration and diffusion of turbulence accompanying jet formation: (*a*) With acceleration the resistance is appreciably less than for the equivalent steady state; (*b*) With deceleration the resistance is appreciably more than for the equivalent steady state; (*c*) For intense jet action as obtained with small orifice-to-tube-diameter ratios it appears that unsteadiness produces an internal flow structure that is no longer comparable to any steady-state condition.

Management

Elements of Job Environment Needing Minimum Standards of Control, by I. Matelsky, General Electric Company, Cleveland, Ohio. 1955 ASME Semi-Annual Meeting paper No. **55—SA-33** (multilithographed; available to April 1, 1956).

Let us take an objective look at a worker at his job. His health, well-being, and efficiency are being influenced by the things that are around him—his job environment. These environmental factors are divided, in this presentation into four general categories: (1) Chemical, (2) physical, (3) biological, and (4) psychological. The paper discusses each of these groups briefly and points out the needs for control.

One need only to think of the greatly increased use of organic solvents, refrigerants, diluents, plasticizers, and paints, to mention a few, to realize how important it is to know their effect upon our health.

There are several channels thorugh which a material (chemical) can affect us: (1) Through inhalation, (2) through ingestion, (3) through skin absorption and sensitivity.

In any plant where materials are being processed, some of the material in the form of dust, fumes, vapors, mists, or gases will get into the surrounding air and be inhaled by people working there. Some of these contaminants, such as carbon tetrachloride, mercury, lead, and silica, can be extremely harmful to an exposed worker. Others, such as coal dust, calcium carbonate, and magnesium oxide, are relatively nontoxic and are usually classified as nuisances. But even a nuisance can indirectly be harmful if the concentration and exposure to it become excessive.

Many materials, especially those that have a corrosive action on the skin and those that are known for their organic solvent properties, can be absorbed through the skin to cause symptoms of systemic damage. Indiscriminate use of degreasing agents defat the skin causing dryness and lesions that are subject to infection.

The effects of the physical agents in the working environment on the workers' health and well-being are for the most part more subtle than those of the chemical agents. No definite criteria of physiological responses have been established and much of the control measures are dependent upon "trial-and-error" treatment and upon "educated guesswork."

Fatigue and the inability to do work properly can be attributed directly to such factors as noise, faulty illumination, excessive heat, and the impurity of the air. Irreparable damage can be caused by excessive noise and ionizing radiations.

For many years the beneficial effects of good illumination have been known. These are principally greater accuracy in workmanship, increased production, greater ease of seeing, improved morale, more easily maintained sanitation in the plant, and greater safety for the workers.

Recently interest has been shown by some industries in the problem of excessive temperature of the working environment. The processing temperatures found in some industries are sufficiently elevated as to cause adverse physiological effects if exposures to them were not controlled. These effects can range from discomfort and weakness to the more serious aspects of heat stroke and heat exhaustion. Exposure to elevated temperatures has a deleterious influence upon physical activity and indirectly on accidents and rates of absenteeism. As temperatures increase, physical work becomes progressively more difficult, with a resultant decrease in production.

Another phase of occupational health, long neglected, but now reaching a station of importance is the effect of certain psychological stimuli on the worker which elicit untoward physiological responses. These factors are subtle, but few of us doubt the increase in morale and the decrease in boredom and accidents when industry changed from dirt-hiding dark colors to the more pleasing pastel shades in their plants. Nor can anyone seriously find objection to the use of "canned music" in the plant to cover the monotony of the dull background noises.

Engineering Control of Occupational Health Hazards, by Benjamin F. Postman, Employers Mutual Liability Insurance Company, New York, N. Y. 1955 ASME Semi-Annual Meeting paper No. **55—SA-57** (multilithographed; available to April 1, 1956).

The industrial hygiene engineer is responsible for the suppression or elimination of occupational health hazards at their source of generation and the prevention of the ever-present exposure to flash fires and explosions resulting from the abuse in the handling of flammable chemicals and explosive dusts. But he cannot do this job alone. He needs help and co-operation from management to provide necessary budgetary allowances and to co-ordinate the formulated policies by an integrated follow-through by plant manager, superintendent, personnel director, physician, nurse, and line foreman.

One thing is certain, every type of occupational health exposure may be adequately controlled. In many instances, it is not the lack of finances, but the lack of the right mental attitude which seriously interferes with the furtherance of a constructive occupational health-control program.

There are many materials used in industry today which may be potentially harmful to the health of industrial workers. The careful development of proper and adequate engineering control means that each problem encountered requires a tailor-made analysis. This factor should never be lost sight of, for there may be occasions when a life may depend upon the effectiveness of the installed control.

As a basis for approach to this problem, it may be stated:

1 Commercial equipment is available to aid in this control to a degree not dreamed of even a decade ago.

2 Engineering experience is available to apply this equipment properly for either simple or involved exposures.

3 Mental attitudes are slowly but surely changing because the economic aspects of the adequate control of occupational health hazards are now realized as an integral part of the cost of industrial operations.

Metal Processing

The Effects of High-Frequency Vibrations in Grinding, by L. V. Colwell, Mem. ASME, University of Michigan, Ann Arbor, Mich. 1955 ASME Semi-Annual Meeting paper No. **55—SA-12** (in type; to be published in Trans. ASME).

This investigation was made for the purpose of exploring possible effects of vibration in grinding including those conditions which do not cause "chatter." As one possible approach to the problem, vibrations were induced artificially between the workpiece and the grinding wheel by vibrating specimens with an ultrasonic transducer.

The results of the investigation definitely demonstrate that small vibrations at high frequencies can improve surface finish, can reduce temperature in the ground surface, can reduce the incidence of thermal cracks, and can mimimize the

effects of variations in hardness within a grinding wheel.

The investigation indicates the possibility of applying high-frequency and even ultrasonic vibrations to selected operations to improve the grinding process. It would also appear to explain some of the well-known characteristics of grinding associated with the use by precision-grinder operators of sound or noise as an indication of the process.

The Role of Chip Thickness in Grinding, by G. S. Reichenbach, Assoc. Mem. ASME, and M. C. Shaw, Mem. ASME, Massachusetts Institute of Technology, Cambridge, Mass., J. E. Mayer, Jr., Research and Development Command, U. S. Army, Natick, Mass., and S. Kalpakcioglu, Assoc. Mem. ASME, Istanbul, Turkey. 1955 ASME Semi-Annual Meeting paper No. **55—SA-37** (multilithographed; to be published in Trans. ASME; available to April 1, 1956).

Grinding chips are classified into five types depending upon their relative thickness-to-length ratio and equations are derived for computing the length or thickness of chips of all types for external-surface, internal, and plunge-grinding operations. Representative experimental grinding data are presented and discussed to illustrate the use of the equations and to emphasize the importance of chip thickness as a grinding parameter.

The force on a single grain is derived and the result applied to explain relative wheel hardness.

Inorganic Grinding Fluids for Titanium Alloys, by M. C. Shaw, Mem. ASME, Massachusetts Institute of Technology, Cambridge, Mass., and C. T. Yang, Ford Motor Company, Dearborn, Mich. 1955 ASME Semi-Annual Meeting paper No. **55—SA-39** (multilithographed; to be published in Trans. ASME; available to April 1, 1956).

Dilute aqueous solutions of certain inorganic salts are very effective in decreasing the rate of grinding-wheel wear and providing decreased surface roughness in the finishing of titanium-alloy surfaces.

A systematic study of a large number of salt solutions has revealed that such solutions act by the formation of adsorbed cationic and anionic layers on the aluminum-oxide and titanium surfaces, respectively. These layers prevent the abrasive and chip surfaces from coming close enough together to form strong bonds, which when broken, remove pieces of abrasive from the system.

In the choice of a suitable material, ion size and effective charge are found to be two items of major importance. Barium was found to be the most effective element in the periodic table for adsorption on aluminum oxide, while the phosphate radical was the most effective anion investigated for adsorption on a titanium-alloy surface. Long chains attached to each of these ions should increase the effectiveness of the simpler ions considered here.

The relation between corrosion inhibition and the screening of titanium surfaces in grinding is discussed.

The Mechanism of Crater Wear of Cemented Carbide Tools, by K. J. Trigger, Mem. ASME, and B. T. Chao, University of Illinois, Urbana, Ill. 1955 ASME Semi-Annual Meeting paper No. **55—SA-11** (in type; to be published in Trans. ASME).

This paper presents an analysis of tool-wear data in terms of fundamental variables consistent with the nature of the contact and rubbing of clean metallic surfaces. Wear of cemented-carbide tools on the top surface is examined in the light of the mechanism of frictional wear as proposed originally by Holm and recently as modified by Burwell, Strang, and Archard.

It has been found that wear at the top surface is essentially of the transfer type and that the formation of crater wear is strongly temperature-dependent. For a given tool-work combination, the top face wear can be correlated with tool-chip interface temperature in a manner predictable from the simple laws of adhesion wear in combination with the theory of rate process.

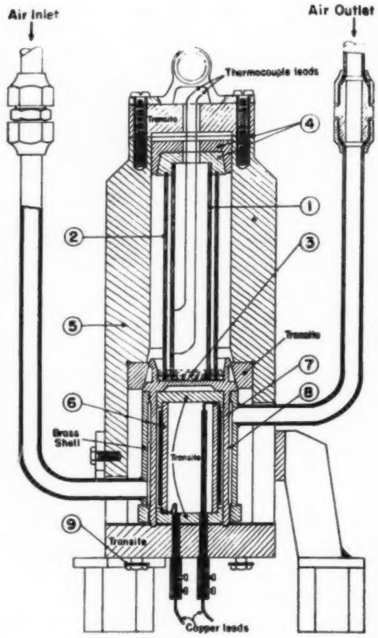
Metals Engineering

Measuring the Thermal Diffusivity of Metals at Elevated Temperatures, by B. T. Chao, University of Illinois, Urbana, Ill., and M. A. El-Hifni, University of Alexandria, Alexandria, Egypt. 1955 ASME Semi-Annual Meeting paper No. **55—SA-36** (multilithographed; available to April 1, 1956).

The Angström-bar method has been modified and adapted to the measurement of thermal diffusivity of metals for temperatures ranging from 300 to 1050 F.

A small, sinusoidal temperature fluctuation is superimposed on the mean temperature of a thin-wall tubular specimen by means of simultaneous heating and cooling at one end. Thermal diffusivity was calculated from the phase shift and amplitude ratio of the temperature waves determined at two measuring stations. The effect of possible surface heat loss is considered.

Measurements were made on AISI 1018,



Experimental apparatus used in measuring the thermal diffusivity of metals at elevated temperatures. The tubular specimen (1) is 5 in. long, $^7/_8$ in. OD, and has a relatively thin wall to insure one-dimensional heat flow. Mounted concentrically with the specimen is another tube (2) of similar material which minimizes the surface heat loss from the test specimen. One end of the tube-and-shield assembly was immersed in a liquid heating bath (3) to maintain a uniform temperature over the tube cross section at any given instant.

1045, 3140 steels, and 1.1 per cent carbon tool steel.

Results obtained for electrolytic tough pitch copper and 2S aluminum showed good agreement with a recent theory of Storm concerning the variation of thermal diffusivity of simple metals with temperature.

The Relations Between Grinding Conditions and Thermal Damage in the Workpiece, by R. S. Hahn, Mem. ASME, Heald Machine Company, Worcester, Mass. 1955 ASME Semi-Annual Meeting paper No. **55—SA-60** (multilithographed; to be published in Trans. ASME; available to April 1, 1956).

The tendency of heat checks and cracks to form in the workpiece is shown to be strongly dependent upon work speed. Durability of the cutting edge of tools is shown to be affected by the work speed during sharpening.

Based on the rubbing-grain hypothesis, the "Theory of Heat Conduction" is

applied to the grinding process to show that lower surface temperatures occur when grinding is done at high work-surface speed.

On the Relations Between Various Laboratory Fracture Tests, by E. M. Lape, General Electric Company, Lynn, Mass., and J. D. Lubahn, Mem. ASME, General Electric Company, Schenectady, N. Y. 1955 ASME Semi-Annual Meeting paper No. **55—SA-70** (multilithographed; to be published in Trans. ASME; available to April 1, 1956).

A GREAT variety of tests were examined with the objective of finding correlations between different kinds of tests. The tests considered included notched and unnotched tensile tests, notched and unnotched bend tests, notched and unnotched disk bursting tests, and Charpy impact tests.

General correlation was obtained in only one instance, and in a few other test comparisons, correlations could be obtained only for certain metallurgical conditions.

A great deal of additional work in this field is required.

Materials Handling

Container Size and Pallet-Pattern Selection Criteria for Use on 40-In. × 48-In. Pallets, by C. J. Heinrich, Mem. ASME, and J. P. Akrep, U. S. Naval Supply Research and Development Facility, Naval Supply Depot, Bayonne, N. J. 1955 ASME Semi-Annual Meeting paper No. **55—SA-8** (multilithographed; available to April 1, 1956).

BECAUSE of the Navy's interest in improving its efficiency in moving supplies and in its warehousing phases, it has been possible to investigate pertinent problems in complete detail and to make investigations on a technical basis. A graphic chart, Naval Supply Research and Development Drawing No. SED-506, has been developed which indicates immediately, by knowing only the bottom length and width of practically any size container to be used on a 40-in. × 48-in. pallet, the best possible pattern and the space use efficiency of that container when used in that pattern. The chart also indicates at the same time by mere visual observation the changes in efficiency which would result if changes in the container size are permissible.

Use of this chart by the Navy is expected to permit the identification, specification, and thus mandatory utilization where practical of most efficient container sizes and pallet patterns on standard 40-in. × 48-in. pallets in order to insure maximum use of warehouse and transportation space in the systems. It is not sufficient to permit production people and warehousemen to stack boxes and containers in any old fashion on a pallet. The loss in cube can amount to 10 per cent or more, and will be appreciable in a large operation. For this reason a selection system was required to insure maximum use of the cube available.

Possibilities opened up by the new method of selection should bring about a continuing improvement in pallet-pattern efficiency and in container-size standardization. In addition, it is also hoped that such a selection-chart system will assist in furthering pallet and materials-handling-equipment standardization.

Maintaining the Automated Plant, by N. K. Conrad, Ford Motor Company, Cleveland, Ohio. 1955 ASME Semi-Annual Meeting paper No. **55—SA-43** (multilithographed; available to April 1, 1956).

A GOOD number of departments in Ford Motor Company plants are automated 100 per cent. This means that with this new tool "automation" used by Ford manufacturing departments a new method of "productive maintenance" must be employed. In the past, machinery or equipment was not repaired until it had broken down. This approach is not satisfactory today. The entire production system is geared to a uniform production rate per hour with little possibility of making up lost production due to breakdowns. Constant productive maintenance is the key to uninterrupted high-quality production. Ford found that, to gain fast, efficient maintenance service in the Cleveland Engine Plant, decentralization of maintenance activities was a must.

Instead of having one central shop trying to service this million-square-foot plant, it is divided into five productive maintenance areas.

Each area has one man responsible for all the maintenance of that area over a 24-hr period. He in turn has foremen on each shift responsible to him. The men required to run these departments are chosen for their ability to keep them in first-class condition and to recognize the signs of threatening trouble. Hourly workers also are assigned to each specific area. With this arrangement, both supervision and hourly personnel are thoroughly acquainted with the equipment and top efficiency is obtained. By having constant productive maintenance on machinery and equipment, the company soon determines any perishable parts that must be stocked for special equipment and machine tools along with standard maintenance stock.

Some examples of cost control are as follows:

1 Every week a detailed maintenance cost report is issued to each area, making it possible for production and maintenance personnel to check and compare costs of their particular area.

2 Cost of a rebuild or a troublesome job may be determined in detail simply by a telephone call or communication.

3 The weekly cost and year-to-date cost of the ten machines or pieces of equipment having the highest cost for that week is issued to the plant manager and each department manager on a weekly basis.

4 The company has been able to break out detailed spindle cost of machinery by department and plant, comparing costs per engine for precision spindles in machining of six-cylinder versus eight-cylinder engines.

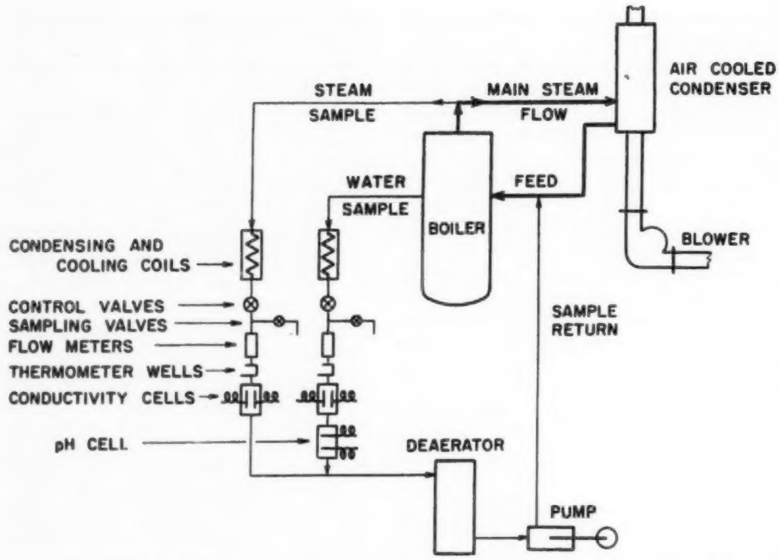
Another aid in the productive-maintenance program is a standards program. This includes standardization of materials, processes, industrial equipment and methods, and specifications which in turn simplifies the problem of keeping adequate replacement supplies in stock.

Power

Selective Silica Carry-Over in Steam, by E. E. Coulter, Assoc. Mem. ASME, and E. J. Wagner, Jr., Assoc. Mem. ASME, The Babcock & Wilcox Company, Alliance, Ohio, and E. A. Pirsh, The Babcock & Wilcox Company, New York, N. Y. 1955 ASME Semi-Annual Meeting paper No. **55—SA-19** (multilithographed; to be published in Trans. ASME; available to April 1, 1956).

STUDIES of power-station operating problems have shown that troublesome turbine-blade deposits, composed principally of silica, are formed under certain conditions of boiler operation. The severity of the silica-deposit problem has been observed to increase with increasing silica concentration of the boiler water and increasing operating pressure. The work of a number of investigators has shown that silica carry-over under such conditions is selective, the ratio of the amount of silica in the steam to that in the boiler water being greater than the corresponding ratios for other boiler-water constituents. Such selective carry-over is generally believed to be due to vaporization of silica from the boiler water into the steam.

Although the problem has been investigated widely, the previous data are not complete over the range of modern boiler operation, and often the data of several investigators fail to agree.



Flow diagram of silica carry-over test apparatus. Principal components of the test apparatus were a small electrically heated, natural-separation boiler, an air-cooled condenser, and sampling systems for boiler water and steam. The equipment was designed for a maximum pressure of 3200 psi and a maximum steaming capacity of 100 lb/hr at 2500 psi.

Therefore, as the first logical step in searching for a solution of the selective silica carry-over problem, a test program to determine the distribution ratios of silica concentrations in steam to those in boiler water over a wide range of conditions was undertaken and completed.

The distribution ratios of the concentrations of silica in steam to those in boiler water were determined over a range of pressures from 300 to 3140 psi, of silica concentrations in the water from 12 to 1000 ppm, and of pH values of the water from 7.8 to 12.1. Mechanical carry-over, determined by using a radioactive tracer, was insufficient to necessitate corrections to the vaporous silica carry-over data at pressures above 500 psi.

A Comprehensive Training Program for Power-Plant Personnel, by Harold Grasse, Mem. ASME, Black & Veatch, Kansas City, Mo. 1955 ASME Semi-Annual Meeting paper No. **55—SA-41** (multilithographed; available to April 1, 1956).

Efficient and reliable electric-power generation is dependent upon competent engineering design and adequately trained operating personnel. Plant design represents the best compromise between capital expenditure and generating costs and includes instrumentation, safety devices, warning systems, and stand-by equipment to enable the operators to operate the station at design conditions. Yet, too often, operators are expected to operate a new plant efficiently without specific training because it is assumed that previous operating experience constitutes adequate training.

This paper describes an extensive training program for power-plant operators and includes its organization, the preparation of operating instructions, and the methods used to teach the subjects in the classroom and during start-up.

Operators having limited experience in existing stations were trained in eight months to operate a new unit plant. Their level of proficiency after this training was equivalent to, and perhaps greater than, that which they might have attained only after several years of operating experience.

The Design of Boiler Furnaces for Combination Fuels, by P. R. Grossman, Mem. ASME, The Babcock & Wilcox Company, Alliance, Ohio, and G. W. Kessler, Mem. ASME, The Babcock & Wilcox Company, New York, N. Y. 1955 ASME Semi-Annual Meeting paper No. **55—SA-73** (multilithographed; available to April 1, 1956).

In recent years there has been an increasing demand for boilers designed to fire more than one fuel and, consequently, many of the latest designs incorporate separate or combination firing of solid, liquid, and gaseous fuels. Such designs may, because of the modifications and compromises required to meet the peculiarities of several fuels, cost more than units designed to fire only one fuel. Yet, the over-all economics justify these designs, many of which can initially fire only oil or gas but are arranged for possible future conversion to coal firing.

Based upon recent practice, the studies of available designs, and continuing research, the following conclusions are drawn:

1 Combustion requirements when firing multifuels are important, but they alone do not govern furnace design. Instead, the heat-absorption requirements in the furnace determine over-all size and arrangement.

2 Furnace designs for multifuel firing are usually established to meet the requirements of the fuel most difficult to burn, but furnaces and boiler components must be designed for the worst characteristics of any of the fuels.

3 Installation of water or steam-cooled surface in the furnace facilitates the use of high heat-release rates and reduces furnace size.

4 Type of firing equipment influences the design of boiler furnaces for multiple-fuel firing.

5 Furnaces for multifuel firing are usually larger and may be more expensive than those designed for only one fuel.

6 Availability of significant quantities of petroleum coke and pitch, and coal char, is dependent upon technological advances in oil refining and coal carbonization processes. If appreciable quantities become available, this may lead to future low-cost boiler fuels. Field and laboratory tests are under way to establish the best methods of burning these fuels, either separately or in combination with the primary fuels.

7 Cyclone furnaces can be modified to appreciably reduce the air-pressure requirements for oil firing, and the modified design can be converted to coal firing with a minimum of change, cost, and outage time.

8 The over-all economics based primarily upon shifting fuel markets and uncertain future developments justify the use of furnaces designed to fire multifuels, separately or in combination.

Margins for Improvement of the Steam Cycle, by J. E. Downs, General Electric Company, Schenectady, N. Y. 1955 ASME Semi-Annual Meeting paper No. **55—SA-76** (multilithographed; available to April 1, 1956).

This paper presents heat-rate improvements obtainable in steam-power stations

from increases in initial pressure to 10,000 psig, increases in initial temperature to 1450 F, and increases in reheat temperatures to 1400 F.

The effect on heat rate of turbine size, reheat pressures, final feedwater temperature, multiple reheat, and other variables is included.

Potential gains from the combined steam and gas-turbine cycle are discussed briefly.

Accelerated Loading of Large High-Pressure, High-Temperature Turbine-Generators, by W. C. Beattie, Mem. ASME, J. M. Driscoll, Mem. ASME, and M. Salvage, Assoc. Mem. ASME, Consolidated Edison Company of New York, Inc., New York, N. Y. 1955 ASME Semi-Annual Meeting paper No. **55—SA-63** (multilithographed; available to April 1, 1956).

With the advent of large-capacity turbines operating at high pressure and temperature, present low rates of loading require hours to bring these units to their full capacities.

This paper discusses the results of high rates of loading tests conducted while independently heating horizontal flanges and bolts of turbine cylinders by admitting live steam under controlled pressure to the annular space surrounding the horizontal flange bolts, and shows how existing loading rates can be increased sixfold with a simultaneous reduction in cylinder flange and bolt stresses.

The following conclusions from the results of the starting and loading tests on single and double-shell, high-pressure, high-temperature turbines are presented:

1 To avoid overstressing of horizontal flanges and bolts during the loading period of a start made after a week-end shutdown, the permissible rate of maximum loading has to be kept so low that it is neither reasonable nor practical, especially for large-capacity units.

2 To permit reasonable rate of loading following a week-end shutdown, it is necessary, in order to avoid overstressing of flanges and bolts and to keep spindle and cylinder differential expansion within limit, to heat the cylinder horizontal flanges and bolts independently in addition to the heat conducted from within the cylinder.

3 To avoid overstressing of horizontal flanges and bolts during the loading period following a 15-minute start after an overnight shutdown, loading rate should be kept below one megowatt per minute.

4 By heating the flanges and bolts independently during the loading period following a 15-minute start after an overnight shutdown, it is possible to increase the loading rates to 3 or more megawatts per minute.

Demineralized Make-Up for 1250-Psi Installation at East Millinocket Mill of Great Northern Paper Company, by E. F. Davidson, Stone & Webster Engineering Corp., Boston, Mass. 1955 ASME Semi-Annual Meeting paper No. **55—SA-75** (multilithographed; to be published in Trans. ASME; available to April 1, 1956).

In 1952 the Great Northern Paper Company planned an increase in manufacturing capacity at its East Millinocket (Maine) mill from 325 to 900 tons per day of newsprint, necessitating an enlargement of its steam-generating plant. Results of studies showed that new boilers should supply 1250-psi, 850-F steam to noncondensing extraction turbine-generators, and that the maximum amount of by-product power should be generated up to the limitation imposed by steam flow through the turbines as required for process. The problem of supplying relatively large quantities of feedwater make-up of suitable quality was a major consideration. Shortly before 1952 a number of high-capacity water-treatment installations of the demineralizing type had been installed, which provided operational background for justifying the 1250-psi steam plant from this standpoint.

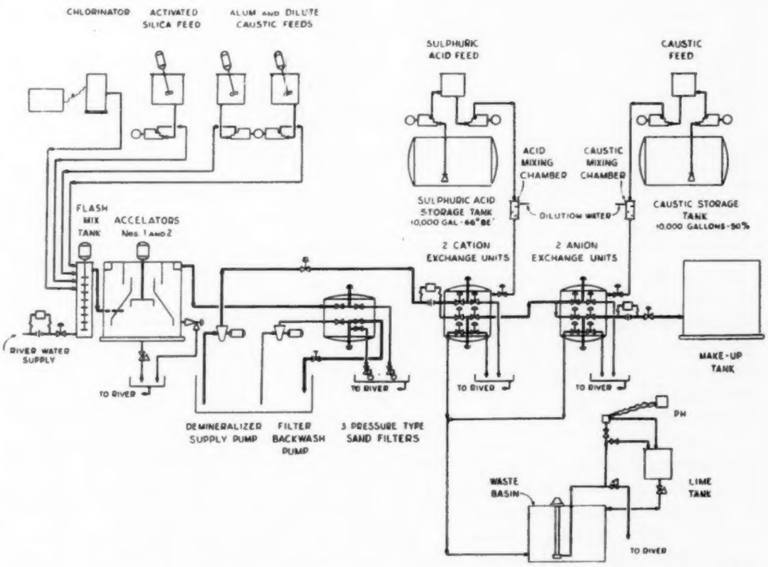
The demineralizing equipment used includes duplicate two-bed demineralizers, each consisting of 6-ft-diam cation and anion exchange units containing 70 cu ft of Nalco HCR high-capacity polystyrene resin and 85 cu ft of Nalco SBR Type I highly basic resin, respectively. Manifolds are equipped with Conoflow air-operated Saunders valve nests. Other equipment includes cycle timers for automatic control during regeneration, strong acid and caustic controlled volume pumps, regenerant mixing chambers, controls, and instruments. Semiautomatic operation is provided with push-button initiation of regeneration cycles and return to service. Maximum flow rate of 200 gpm is obtained through one pair of exchangers during regeneration of the second pair.

Horizontal steel tanks are installed for storage of 10,000 gal each of 66 deg Bé sulphuric acid and 50 per cent caustic.

Process Industries

Part-Load Performance in Centrifugal Refrigeration, by A. M. G. Moody, Mem. ASME, The Trane Company, LaCrosse, Wis. 1955 ASME Semi-Annual Meeting paper No. **55—SA-54** (multilithographed; available to April 1, 1956).

Meeting part-load demands poses two major problems to the designer of a centrifugal compressor. The first is the elementary problem of how to operate the machine at all. Because of the minimum-capacity limitation imposed by surging, the compressor, lacking other means of



The simplified flow diagram of the pretreatment and demineralizing plant designed and installed at East Millinocket to produce boiler feedwater make-up from Penobscot River water is shown. All equipment is installed indoors for convenience of operation and protection against freezing.

capacity control, would have to shut down frequently, which might well be intolerable. Consequently, it is of paramount importance to find a means to extend the operating range.

As soon as this is done, the second problem arises, namely, how to reduce the specific power consumption at part load.

Regardless of the means used to control capacity, the possibility of short cycling must be considered. This would not be so if stable operation at zero load were practical, but this is not the case with present control means.

Cycling, that is, starting and stopping, if too frequent, is both annoying and dangerous. The life of a motor is largely dependent on its operating temperature, and frequent starting will raise the temperature. It is impossible to set a definite limit to the frequency of starts, but it is not uncommon to use the figure of three starts per hour as the maximum permissible. This is, of course, arbitrary. Three starts per hour, if continued for many hours, would hardly be beneficial.

Aside from this, it is well known that the wear in sleeve bearings will occur almost entirely at start-up, assuming proper lubrication, since this is the only time when there is no oil film present. Hence excessive frequency of starting ultimately will result in excessive bearing wear.

This paper discusses the problems involved in part-load performance in centrifugal refrigeration. It takes up the air-conditioning application, cycle time, head relationships at part load, designing for overloads, methods for reducing load, and capacity control methods.

The Nonaqueous Process for Portland Cement Manufacture, by J. C. Witt, Fellow ASME, Consulting Engineer, Chicago, Ill. 1955 ASME Semi-Annual Meeting paper No. 55—SA-26 (multilithographed; available to April 1, 1956).

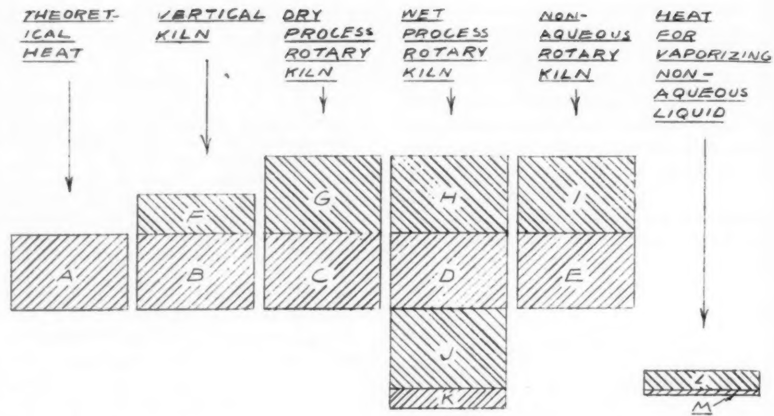
In cement manufacture it has been customary to grind raw materials by either the wet or the dry process. In the new process, developed to combine the advantages of the two existing processes, raw materials are ground in a nonaqueous liquid.

The heat input of a kiln is the sum of the theoretical heat and the additional heat. The diagram shows this relation for each of four types of kilns. A, B, C, D, and E represent the theoretical heat required to produce one barrel of clinker. F, G, H, and I are corresponding additional heats.

The wet-process rotary has the highest heat input, because of J, the theoretical heat for vaporizing the water from the slurry; and K, the corresponding additional heat. In the nonaqueous process dry raw materials enter the kiln. J and K are replaced by theoretical heat L and additional heat M. This greatly reduces the heat input but retains the uniformity of the wet process.

The nonaqueous process is applicable to both raw materials and clinker, but this paper is restricted to raw materials.

Table 1 outlines procedures for reducing heat input.



Heat for clinkering. Heat-input relation for each of four types of cement kilns.

Table 1 The Heat Input of Cement Kilns

Classification[a]	Location[a]	Procedures for decreasing the quantity of heat
Theoretical	A, B, C, D, E	Change in the composition of raw materials, or clinker, or both.
Theoretical	J	Reduction in the quantity of water entering the kiln. Examples: Filters, fluidizers.
Additional	G, H, I	*Direct:* More finely ground raw materials and coal, kiln design, kiln insulation, instrumentation. *Indirect:* Recovery and application of waste heat.
Additional	K	In general, the same procedures as for G, H, I.

[a] This refers to above diagram.

Process Design of Tubular Heaters, by L. A. Mekler, Mem. ASME, Consultant to Petro-Chem Process Company and Petro-Chem Development Company, New York, N. Y. 1955 ASME Semi-Annual Meeting paper No. 55—SA-27 (multilithographed; to be published in Trans. ASME; available to April 1, 1956).

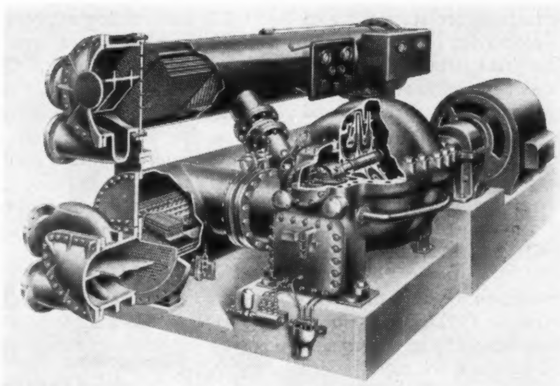
Process tubular heaters are designed to supply to the fluid being processed, usually called "the charge," a definite quantity or heat of a specific quality as determined by requirements of the process. Generally, the charge to the heaters consists of hydrocarbons or other thermally unstable organic fluids which decompose when heated above a certain temperature specific for each fluid. The extent of decomposition depends on the temperature profile or the "heating curve" through the heater and on the time the fluid is at temperatures above that of initial decomposition. The combined influence of time and temperature on the extent of decomposition in the heater is often referred to as the time-temperature effect of the heater.

For thermophysical processes, the heater is designed to avoid decomposition because it will destroy part of the charge and will contaminate the product. Heaters for these processes are therefore designed for a minimum time-temperature effect at the desired outlet temperature.

In thermochemical processes the aim is to decompose all, or a portion of, the charge into specific products and the heater is designed to supply the time-temperature effect required to obtain optimum yields of the desired constituents.

Centrifugal-Refrigeration Industrial Applications by E. Gammill, Carrier Corporation, Syracuse, N. Y. 1955 ASME Semi-Annual Meeting paper No. 55—SA-9 (multilithographed; available to April 1, 1956).

Several thousand large centrifugal-refrigeration machines have been in-



Centrifugal-refrigeration machine. The machine is simple consisting of a high-speed pump-type rotor and outer shell which can be used with the usual evaporator and condenser equipment common to all refrigeration cycles.

stalled since the invention of the machine in 1922.

This paper reviews and discovers some new uses of centrifugal compressors in modern industrial applications. Centrifugals for many special purposes are shown to be available.

Factors are considered for the best economics. Some of them are such considerations as choice of refrigerants, drivers, and the nature of the process.

Rubber and Plastics

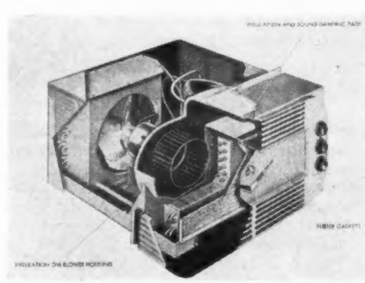
Adhesives—A "Third Dimension" in Fastening and Joining, by Richard S. Piper, Minnesota Mining and Manufacturing Company, Detroit, Mich. 1955 ASME Semi-Annual Meeting paper No. **55—SA-64** (multilithographed; available to April 1, 1956).

Adhesive performance has reached a point where competition with mechanical fasteners and fusion methods for structural joining is now possible. An understanding of the place adhesives occupy in relation to traditional assembly methods is essential if they are to be used to best advantage.

Some typical uses of modern adhesives are described and important design considerations are outlined. Emphasis is on the practical, rather than theoretical, aspects of the subject.

Most of the significant progress in adhesive technology has come since the introduction of synthetic resins and rubbers. Great strides have been made during the past ten to fifteen years in the development of high-performance adhesives from the new synthetic polymers which are reaching commercialization. Simultaneously came the need to bond these new materials as soon as they reached the market. And so, hand in hand, has come the need along with the means to develop new and better adhesives.

Sandwich construction is an excellent example of new design made possible only through the use of adhesives. Sandwich construction consists of a lightweight core, sandwiched between two relatively tough thin skins of metal, plastic, or wood. A great variety of core materials and constructions are in use today. The trend is away from lightweight balsa wood, originally used. Prefabricated core constructions are now coming into common use. Most cores now consist of resin-impregnated paper or cloth or thin metal foils which are constructed in a cellular pattern resembling honeycomb. Such core constructions are sawed "across the grain" into sheets of the desired thickness. Adhesives play a vital role in sandwich construction, both in the assembly of core materials and in the attachment of skins to the cores. These sandwiches, generally made in the form of panels, are contributing to radically different design concepts in aircraft, architecture, and other fields of construction.



Adhesives in air-conditioning manufacture

The light metals, aluminum and magnesium, can now be joined more strongly with adhesives than by any other method. In thin sheets, bond strength may exceed that of the metal itself. Welding of aluminum is not always feasible because it ruins previous heat-treatment and drops the strength of some alloys to less than one tenth that of properly heat-treated stock. Sometimes it is inconvenient or impossible to weld because of inaccessibility or because of proximity to an area which could be damaged by the welding process. Combinations of dissimilar metals or metals with other materials do not lend themselves to welding. Adhesives offer a solution to such assembly problems.

Stress Distributions and Design Data for adhesive Lap Joints Between Circular Tubes, by J. L. Lubkin, Assoc. Mem. ASME, Midwest Research Institute, Kansas City, Mo., and Eric Reissner, Massachusetts Institute of Technology, Cambridge, Mass. 1955 ASME Semi-Annual Meeting paper No. **55—SA-59** (multilithographed; to be published in Trans. ASME; available to April 1, 1956).

This paper presents stress distributions for 48 adhesive lap joints between thin circular tubes loaded in tension. The adhesive is treated as a thin elastic layer, much more flexible than the adherends, so that the analysis applied primarily to the bonding of metals and plastics. Ordinary thin-shell theory is used for the adherends.

The basic theory and the calculated adhesive shear and normal stresses are given, and the significant principal stresses are discussed. The influence of the various system parameters, notably the tube curvature, is considered in some detail, and a comparison is made with previous flat lap-joint results.

Applicability of the theory in joint design is also treated.

Production Engineering

Study of Die Wear by Means of Radioactivated Surfaces, by B. J. Jaoul, École National Supérieure des Mines de Paris, Paris, France. 1955 ASME Semi-Annual Meeting paper No. **55—SA-24** (multilithographed; to be published in Trans. ASME; available to April 1, 1956).

Recent development of the production of radioactive isotopes has given rise to a number of new techniques that may be applied in several fields of science, especially medicine, biology, chemistry, and mechanics.

The study of wear by friction is a very good field for applying radioactivation techniques. Several investigations have

been made on gear wear, ram wear, and so on. In these studies, one of the abrading members is radioactive and the products of its wear may be located in the lubricant. In the study of dry friction, e.g., in cylinders, automobile tires, tools, etc., the radioactive particles may be found on the unactivated member.

In this paper a particular application is explained, namely, the wear of a die face during the hot extrusion of steels.

During the Sejournet extrusion process of the "Comptoir Industriel d'Etirage et Profilage des Metaux" such dies are subject to very severe service conditions. The temperature of the billets may range up to 1300 C and the pressures are about 100 kg per sq mm.

The die, made of a 10 per cent tungsten tool steel, was exposed for about two days to the neutron stream of the atomic pile at Chatillon. The tungsten became radioactive to the extent of about 1.5 mc per gram.

A curie, i.e., the radiation emitted by 1 gram of radium, is equivalent to 3.7×10^{10} rays per sec. It is thus possible to determine the weight of steel of the die which corresponds to a certain level of impulses. All factors being known, 1 mg of die steel had to produce 1500 impulses per min immediately after irradiation. But this value varies with time; while the half-life (24.1 hr) of tungsten is known, other elements may interfere so that it is better to keep a standard for comparison. This control was provided by chips of the same metal which were placed in the atomic pile together with the die and provided a standard for the decreases in radioactivity.

It is thus possible to observe and weigh very small particles of the die metal with an accuracy of about 10^{-6} grams.

Determinations of radioactivity were made on several sides of the extruded bars, giving average wear under normal conditions. In some cases a certain die shape wore by a definite amount per meter, while other shapes wore to an extent that was hardly measurable. The influence of temperature, ingot surface, rate of extrusion, die surface, and lubricant, etc., on die wear was evaluated.

An Effective Cost-Reduction Program, by L. J. Brozek, P. A. Noble, and M. B. Parmelee, Westinghouse Electric Corporation, East Pittsburgh, Pa. 1955 ASME Semi-Annual Meeting paper No. **55—SA-6** (multilithographed; available to April 1, 1956).

To modern industrial management, cost reduction is an important concept, and a useful tool. Currently, many industrial organizations are attempting to establish a continuing cost-reduction program. The Transportation and Generator Division of the authors' company employs approximately 6000 people and manufactures large rotating apparatus, induction regulators, mercury-arc rectifiers, and transportation equipment. The cost-reduction program in this division has resulted in savings on the order of \$10 for each \$1 spent to administer the program.

The cost-reduction organization consists of three groups: (1) Design engineering; (2) purchasing; (3) manufacturing or shop. All groups work closely with one another and co-operate in the cost-improvement effort.

Engineering, purchasing, and manufacturing, each has its own co-ordinator who spends full time on cost reductions. They promote all cost-reduction activities within their departments, keep the personnel cost-conscious at all time, and act as liaison between their own and other departments. The other personnel connected with the program are regular employees who have part of their time scheduled for cost-reduction activities.

Experience with this program indicates a more than adequate return on investment can be realized. Although the benefits of cost reductions extend into future years, the cost-reduction reports are based on only one year's activity. The Transportation and Generator Division builds large apparatus and many of the products are not repetitive. Where activity is high, this program should result in a much better return on investment.

Total number of projects received annually has increased from 1525 in 1950 to 2046 in 1953. Average savings per docket has remained relatively stable over the years. This indicates that opportunities for cost reductions are always present and can be found when proper effort is applied.

Many intangible benefits result from the program, such as (1) improved quality, (2) less material in process, (3) shorter delivery dates, (4) improved customer relations, (5) making available facilities to increase output.

On the Tool-Life and Temperature Relationship in Metal Cutting, by Edward Saibel, Mem. ASME, and F. F. Ling, Assoc. Mem. ASME, Carnegie Institute of Technology, Pittsburgh, Pa. 1955 ASME Semi-Annual Meeting paper No. **55—SA-23** (multilithographed; to be published in Trans. ASME; available to April 1, 1956).

The empirical relationship of Schallbroch, Schaumann, and Wallichs between tool life and cutting temperature is examined in the light of recent developments in rupture theory. Cutting-tool failure is viewed essentially as a rupture process and the data relating tool life and cutting temperature are interpreted from a reaction rate-theory point of view.

The significance of cutting temperature is critically examined and its limitations are pointed out.

Safety

Effective Management Controls Accidents, by A. S. Johnson, American Mutual Liability Insurance Company, Boston, Mass. 1955 ASME Semi-Annual Meeting paper No. **55—SA-30** (multilithographed; available to April 1, 1956).

Plant productivity does not reach a maximum until the occurrence of accidents has been reduced to a minimum. Since accidents are a natural consequence of doing things, preventing them is accomplished by applying certain tools of management as controls to achieve a plan.

Having established a policy, that a plant is to be operated in a safe manner, each division of management responsibility in the several work areas should incorporate accident-prevention activities into its regular production plans. For example, provision of proper guards, and such things as conveyers necessary for safe and efficient operation of machines are frequently left to the mill wrights to worry about after the machinery arrives. Material specifications excluding benzol and other toxic materials from industrial solvents to be purchased, should be provided as a standard for a control laboratory to review supplies that may not be safe to use.

Another illustration is the examination for their safety features of proposed plant processes while still in the drawings and specifications stage. It is a good plan to introduce a simple control by providing a spot for the initialed approval of the staff safety man on such drawings.

The third illustration that represents a plan with its proper control is the provision for a written receipt from a foreman to the die setter, which states that he has made a trial run of a new die setting and found the guards in place and working.

There are literally hundreds of safe procedures to be found in the literature. When adopted, they become part of a plan and control which will tend to make the safety results of the operation predictable almost to certainty. Operating people who do less than plan for

safety in such detail, fail to carry out their responsibility to operate within the policy of safety.

Applying Research to Accident Prevention, by A. L. Brown, Mem. ASME, Factory Mutual Engineering Division, Norwood, Mass. 1955 ASME Semi-Annual Meeting paper No. **55—SA-32** (multilithographed; available to April 1, 1956).

Industry and the insurance business have a common goal in seeking the elimination of accidental fires or explosions. Next best to total prevention, and frequently very effective, is the limitation of damaging effects from fires or other accidents that still occur in the absence of complete prevention. The necessity of preventing small fires from becoming large ones calls for research in loss reduction to develop effective fire-extinguishing methods and other means of minimizing damage.

In the field of fire-loss reduction some representative developments in which research and laboratory tests provided information leading to improved and more positive methods of fire-loss prevention are presented.

The recent outstanding improvement in automatic-sprinkler protection, the development of the so-called automatic-spray sprinkler, occurred as a logical outgrowth of efforts to improve the effectiveness of water for extinguishing fire by using more completely its great heat-absorbing capacity and its property of producing simultaneously a large volume of noncombustion-supporting steam. This has been accomplished by better engineering in the production and application of water spray.

Another development is following recent trends in materials handling and the economic pressure for more complete use of storage space, which have resulted in high-piling of materials and have increased the difficulty in providing effective and practical automatic fire protection.

The Factory Mutual Laboratories have made tests using high piles of combustibles representing textile goods in cartons, automobile tires, and cases of appliances such as refrigerators in cartons or crates.

This type of investigation will continue with still other types of storage. Large-scale tests are time-consuming and costly, but it has not yet been possible to devise tests that can be made on a small scale to truly represent the behavior of actual storage fires.

Still another subject now being investigated by large-scale tests is the determination of the extent to which combustibles used for vapor barriers or insulation on steel deck or other noncombustible roof decks will contribute to an interior fire.

ASME Transactions for August, 1955

The August, 1955, issue of the Transactions of the ASME (available at $1 per copy to ASME members; $1.50 to nonmembers) contains the following:

Technical Papers

Important Considerations in the Use of the Wind Tunnel for Pollution Studies of Power Plants, by G. H. Strom and James Halitsky. (54—SA-41)

Wind-Induced Vibration of a Pipe-Line Suspension Bridge, and Its Cure, by R. C. Baird. (54—PET-12)

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Comments on Papers

Including Letters From Readers on Miscellaneous Subjects

Free-Piston Gas Turbines

Comment by David J. Bloomberg[1]

The prime mover under discussion[2] could be more descriptively called a free piston-free power turbine prime mover, and as such we are now in position to compare it to its counterpart—the dual rotor-free power turbine-gas turbine unit.

In the latter, one of the dual rotors is termed the gas-generator unit. The other unit, normally close coupled to the first unit in respect to gas-flow paths, is mechanically free of the gas-generator unit. This dual-rotor gas turbine is receiving increasing recognition because of its inherent advantages of torque-speed characteristics. The free piston-free power turbine prime mover with similar inherent advantages and also some additional advantages should in time have wider applications.

In general, the main difference between the two prime movers is in the gas-generating part of the cycle.

The piston-type unit is generally better at the lower end of the flow volume scale and this covers ratings up to around 1000 hp. The turbine-compressor gas generator loses out in this portion of the flow volume scale because of the inherently high losses in small flow-path areas.

In many applications the location of the small lightweight turbine close to its load unit will permit the designer more freedom in his layout problems.

Comment by W. V. Nalls[3]

As stated by the author, "In comparison to diesel engines, free-piston machinery has inherent advantages of lower specific weight and lower maintenance costs." Methods to accomplish lower "specific weight" are apt to become quite involved. To compete with new diesel engines now being developed by the Navy, the weight of gas generator-and-turbine combination must be reduced from the present 17.4 lb per bhp to approximately 10 lb per bhp. While the Model "DL" gas generator weighs approximately 12.8 lb per ghp, the weight of the turbine being used for a Navy application raises the total bhp weight to 17.4 lb per bhp. A number of methods will have to be studied to determine the direction in which to go to reduce weight further. Among these are (*a*) supercharging, (*b*) further reduction in weight of gas-generator components, (*c*) use of a specially designed lightweight turbine.

By these methods the 10 lb per bhp target may be met. While weight is not a prime consideration for railroad service, it is for Navy use.

Lower maintenance cost, in so far as the Navy is concerned, can be proved only by installation in a ship, which is scheduled for January, 1956. Lower maintenance costs seem to be inherent in the free-piston gas generator, however.

One very important advantage to the Navy for free pistons over diesel engines is improved speed-torque characteristics. This improvement is largely the result of the use of a hot-gas turbine which has the characteristic of a steam turbine, in so far as torque is concerned.

In regard to flexibility, when using free-piston gas generators, it is envisioned that its use on tenders for the Navy would prove a decided advantage. As these ships have a higher horsepower demand at anchor than under way, free-piston units could supply gas to propulsion turbines or ship service turbo-generators. This would result in far less installed power.

Comment by J. Kenneth Salisbury[4]

The writer's interest in free-piston engines and compound engines in general was intensified by the original development program that has resulted in the unit described by the author. In the recent past he has had a rather intimate relationship with the engine described by the author.

Final proof of the possible ultimate value of free-piston units can be obtained only through actual shipboard installation of such a unit and operational experience. It is planned that the unit described by the author will be installed in a Navy auxiliary vessel. Scheduling of this installation has been in existence for more than a year. A turbine is on order, and the entire set, both free-piston unit and turbine, will be given extensive laboratory tests to supplement separate tests run on both the free-piston unit and the turbine by the respective manufacturers. The Bureau of Ships of the Navy Department is to be complimented for its vision and tenacity in supporting an objective appraisal of the free-piston system through installation of the unit in a seagoing vessel. That favorable answers will be obtained is not a foregone conclusion, but either positive or negative answers will be of considerable value.

Rating of Unit

The author has described the rating of the unit. It is the writer's belief that a true "rating" can be established only by an extensive endurance test. For this reason an extremely rigorous endurance test was devised to simulate actual shipboard operation, including gradual increase in load to full power of 525 ghp, overload, full power, back to light load, and finally shutdown. This pattern was followed through approximately 83 6-hr cycles in the spring of 1953. Some difficulties were encountered during the endurance run, but all parts that failed were ultimately required to last through 500 hr.

Following the endurance test a rating test was run in which the unit was pushed to the limit to determine its present ultimate capacity. The writer suggested this series of tests, but cautioned against using the results as a rating. It was during this test that the unit developed for 2 hr the 830 hp mentioned by the author. Neither this nor the 700-ghp rating mentioned by the

[1] Consultant, Newton, Mass. Mem. ASME.

[2] "Free-Piston Gas-Turbine Prime Movers," by A. J. Ehrat, Mechanical Engineering, vol. 77, March, 1955, pp. 212–216.

[3] Head of Code 431, Specification and Auxiliaries Section, Machinery Design Branch, Bureau of Ships, Navy Department, Washington, D. C.

[4] Professor of Mechanical Engineering, Mechanical Engineering Department, Stanford University, Stanford, Calif. Mem. ASME.

author is considered by the writer to be a valid rating for the unit, since neither is substantiated by an extensive and rigorous endurance test. This remark is not intended to detract from the worthiness of the present effort. It must be regarded as a technicality, albeit an important one in appraising the merit of the unit.

Although the weight of the present unit is a handicap to widespread naval application, the fuel consumption of the present unit is entirely acceptable. Specific fuel consumptions are expected to be comparable with those of equivalent diesel engines, but certainly not outstandingly better, as many seem to think.

Multiple Turbines

The use of free-piston units in multiple with a single turbine has been widely discussed, and is mentioned by the author. The writer has made an extensive investigation to ascertain the validity of the concept. The net conclusion of an investigation made for naval applications is that it is difficult to justify more than about three free-piston units feeding a single turbine. Decreases in turbine efficiency at low gas flows cause serious difficulties and indicate that low fractional loads are better obtained by decreasing the engine exhaust pressure than by installing a larger number of small free-piston units and cutting them out at light loads. This statement is predicated on quantitative studies. It represents the first objection, to the writer's knowledge, to indefinitely subdividing into smaller units the free-piston engine which feeds a single turbine.

Use of Low-Grade Fuels

The author's statement that satisfactory combustion of low-grade fuels is possible, but that it has not been investigated, is reminiscent of many years of optimism in the rotating gas-turbine field. Here we have found that burning low grades of fuel is far more difficult than it appears on the surface. Although this was accomplished in diesel engines a good many years ago, the problem might be quite difficult with the high piston speeds that are required to keep the size of the free-piston unit within bounds. The writer suggests that we proceed with caution in this area.

Selection of a large or small equivalent orifice into which the free-piston unit shall exhaust is indeed a problem. Perhaps the curves of Fig. 1 will illustrate the situation. On this curve, gas horsepower is plotted against equivalent orifice size for various engine-exhaust pressures. Superimposed on this plot are lines of constant load and lines of constant compressor power. Selection of a larger orifice for a given gas horsepower results in lower back pressure, lower scavenge temperature, lower exhaust temperature, but higher flow and higher compressor loading, hence higher diesel-cylinder duty. Selection of a smaller orifice produces opposite results. Obviously, if one wishes to favor the engine, he selects the smaller orifice. This results in higher inlet temperatures to the turbine, not usually a problem in this range. Selection of the larger orifice gives lower scavenge temperature, but increases the duty of the diesel cylinder for a given gas horsepower. The writer subscribes to the author's statement on selection of orifices, and wishes to add that in some instances the selection of a smaller orifice may permit earlier realization of a satisfactory unit through reduction of the diesel-cylinder power for a given net power.

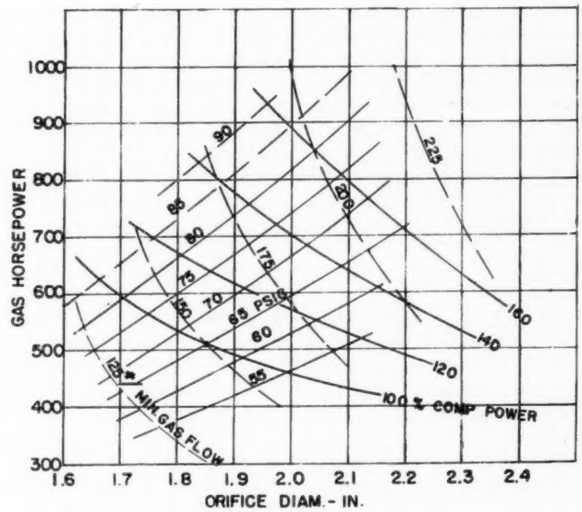

Fig. 1

Comment by J. J. McMullen[6]

In addition to the advantages mentioned by the author, there are several which should be brought to attention, or amplified further; i.e., flexibility of machinery arrangement, excellent power take-off characteristics, and nonrequirement of critical materials.

A wide range of gas-turbine sizes can be accommodated by a single type and size free-piston gas generator, used in multiple numbers; in this manner pressure and temperature limitations normally imposed on the diesel are alleviated and greater horsepowers may be utilized. Such multiplicity of use allows the designer a good deal of freedom in providing total plant horsepower and in planning the machinery layout.

Constant power rather than limited torque take-off is a desirable operating characteristic of the free-piston gas turbine. Since this is attained in addition to utilizing the high efficiency of the diesel cycle for parasitic losses, some of the advantages of both the turbine and diesel are combined into one unit.

Another very considerable advantage of this prime mover is its ability to attain high thermal efficiency without expending critical materials such as nickel, copper, chromium, cobalt, etc. Although some chromium is required in the turbine blading, due to the low inlet-gas temperature, it is a relatively small amount as compared with alloys of the conventional open-cycle gas turbine. As for critical materials in the free piston, these are of such small quantities they may be considered negligible.

The free-piston gas-generator-turbine efficiency under the present state of the art is comparable to that of a standard diesel engine. Taking into account its relative infancy it is expected that refinements will make it even surpass the diesel in the future.

Another development which offers promise is the utilization of afterburning. By so doing, it is possible that approximately a 30 per cent increased power output may be obtained for a 10 per cent increase in specific fuel consumption.

One other point which the writer

[6] Chief, Office of Ship Construction and Repair, U. S. Department of Commerce, Maritime Administration, Washington, D. C. Mem. ASME.

would like to stress is the necessity for burning untreated residual oil in the free piston. Continued use of diesel oil or special residuals will put the free piston at a distinct disadvantage, since the trend in both diesels and gas turbines is toward burning bunker oil and the great difference in cost between bunker and diesel oil would certainly be a deterrent to free-piston applications.

Author's Closure

As Mr. Nalls indicates, the free-piston gas turbine is subject to considerable competition from the lightweight diesel engines now being developed. Naturally this situation is of some concern. On the other hand, perhaps the answer to this point lies in Mr. McMullen's reference to the relative infancy of the free-piston engine.

We should remember that the greatest recent progress in the diesel-engine field has been effected through the development of supercharging. It is the author's considered opinion that, with a reasonable amount of well-directed effort, supercharging may be applied as successfully to the compressor cylinders of free-piston gasifiers as it has been to conventional diesel engines. Although other methods of reducing specific weight also are worthy of pursuit, at the present time supercharging seems to hold the greatest promise for the future.

Professor Salisbury's comments relative to the power rating of the basic Model DL gasifier are appropriate, but the author wishes to point out that the rating of prime movers is an indefinite quantity which depends on very many factors. These might include: The load schedule; the desired life; the type of installation; and human decisions as to whether the machine should be rated at "full load" with an allowance for "overload," or whether it should be rated at peak load. In view of the preceding, and in view of the fact that only emphasis on other more important work prevented the running of additional extensive tests on the DL gasifier, the author maintains that the 700 ghp is a valid nominal rating. The 830-ghp value mentioned in the paper was not meant to be misconstrued as a rating. It was quoted merely as an indication of the power which thus far has been delivered by the gasifier.

The question of equivalent orifice size is not nearly so clear-cut as has been stated, in that higher flow and higher compressor-cylinder loading do not necessarily increase the effective loading of diesel-cylinder components. That is, the power which a given diesel cylinder can deliver without distress depends not only on its displacement but also on its load-carrying ability. The latter is a function of interrelated quantities such as scavenging efficiencies, charge temperatures, and entrapped air-fuel ratios. Were it not for this concept the highly supercharged diesel engines as we know them today would not be possible.

It is agreed that the use of more than three gasifiers per turbine may not be justifiable from the standpoint of efficiency, but it is not agreed that multigasifier plants are difficult to justify on the bases of greater flexibility of arrangement and operation and of greater possibilities of delivering large amounts of power to a single shaft. In the author's opinion large multigasifier power plants provide the most desirable applications for free-piston gasifiers.

The author's statement that combustion of low-grade fuels had not been investigated applied specifically to the Model DL gasifier. The fact that the use of lower-grade fuels is possible and practical is indicated by an article[6] in the technical press.

A. J. Ehrat.[7]

Shock Mounts

Comment by Charles E. Crede[8]

This paper[9] is a welcome addition to the technical literature on the subject of mechanical shock. Our understanding of this subject seems to have been hindered by both an oversimplification and an undersimplification. Many workers in this field apparently have failed to realize that it is relatively unimportant to describe a shock motion, but relatively important to consider the effect of the shock. A previous paper by the authors, reference (1) of the present paper, contributed materially to pointing out this important fact. The present paper continues in the same vein and adds a still better understanding of this practical and valid viewpoint.

With regard to the protection afforded by shock mounts, the degree of protection tends to increase as the permissible deflection of the mount increases. This may be deduced from the paper by comparing Fig. 6 with Fig. 7, and Fig. 8 with Fig. 9. In general, the ordinate of the spectrum decreases as the travel of the shock mount increases. This relation is derived from the fact that, in the type of test conducted by the authors, the shock mount must move the mounted equipment ahead of the mounting plate of the shock machine. Consequently, the shock mount must store a quantity of potential energy equal to the ultimate kinetic energy of the mounted equipment. This is proportional to the area under the force-deflection curve. Under these circumstances the force transmitted by the mount decreases when the deflection of the mount increases. The transmitted force is not directly proportional to the ordinate of the shock spectrum because frequency effects, which often are of second order, contribute somewhat to the shape of the spectrum.

It is interesting to note the authors' technique of changing the frequency of the transient vibration embodied in the input shock. The paper does not reveal numerical values for the frequencies of the transients, nor does it illustrate their effect on the shock spectrum. It would be interesting to see the order of magnitude of the variations in the shock spectrum that were eliminated by averaging the spectra obtained from the various input conditions. Another type of transient involved in this input occurs when the motion of the mounting plate is arrested. There is some indication that the period required for full travel of the mounting plate is of the same order of magnitude as the natural period of a typical shock-mounted system. If this assumption is correct, it seems possible that the effect on the shock spectrum may be substantial and may change the order of the spectra among several mounts with different natural frequencies.

Heat Processing

Comment by Stanley M. Lausch[10]

The increase in production output has caused the speed-up of many mechanical handling systems. This development ties in as more than a coincidence with the high-temperature radiation and direct-flame-impingement heat-processing applications described in the paper.[11]

The use of a high-temperature head on the product in process requires its fast

[6] "First Merchant Ship With Free-Piston Engines, Propulsion of a Coastal Vessel by Twin GS-34 Gasifiers Burning Residual Oil," *The Oil Engine and Gas Turbine*, vol. 22, no. 252, June, 1954, pp. 71–72.

[7] Baldwin - Lima - Hamilton Corporation, Hamilton, Ohio.

[8] Vice-President and Chief Engineer, Barry Controls, Inc., Watertown, Mass. Mem. ASME.

[9] "Evaluating Shock Mounts," by J. P. Walsh and R. E. Blake, Mechanical Engineering, vol. 77, March, 1955, pp. 231–235.

[10] Public Service Electric & Gas Company, Paterson, N. J.

[11] "Heat Processing Combustible Material," by C. P. Mann, Mechanical Engineering, vol. 77, March, 1955, pp. 219–228.

travel in and out of the heat zone or across the heat source. Higher temperatures provide the desired effect in a safe controlled method that is coordinated with the travel of the web, sheet, or strip.

The compact design of intense combustion methods as compared with the old arrangement of lower-temperature heads in slow-moving methods shows that the work can be done with reduced maintenance and less floor space. It has been demonstrated that the gas operating cost is spread over a greater volume of production that averages as well as or lower than the replaced methods. In cases where the average cost is higher there are usually other benefits to the product or operation that justify the increase.

These quick, unique methods of heat release and direction for the processing of combustible materials indicate the growing use of a valuable tool in our technological advance.

Reviews of Books

And Notes on Books Received in Engineering Societies Library

Titanium

Titanium in Iron and Steel. By George F. Comstock. Published for The Engineering Foundation by John Wiley & Sons, Inc., New York N. Y.; Chapman & Hall, Ltd., London, England, 1955. Cloth, $5^1/_2 \times 9$ in., figs, tables, bibliography, name and subject indexes, xii and 294 pp., $6.

Reviewed by Ward W. Minkler[1]

This is the third publication of the Iron Alloy Committee of The Engineering Foundation in their Alloys of Iron Monographs. Like the previous volumes, "Aluminum in Iron and Steel" and "Nickel in Iron and Steel," this book will be one of the primary reference sources for the ferrous metallurgist.

After a short general discussion of titanium ores and their preparation, the author examines the properties and effects of titanium as an alloy addition to cast iron and steel. The effect of titanium on stabilizing nitrogen and carbon as well as its deoxidizing effects in ferrous alloys are reviewed.

Mr. Comstock includes a chapter on the effect of titanium on the precipitation-hardening steels and complex heat-resisting alloys such as Nimonic 80 and 19-9DL.

However, the book is not intended to be of value only to the high-temperature ferrous metallurgist. The author has thoroughly reviewed the use of titanium in rimmed steel, pearlitic steels, cast iron, and steels that are to be enameled.

Mr. Comstock and the Iron Alloy Committee have done an outstanding job in assembling the important data that have been accumulated on titanium in its role as an increasingly important alloying addition in the manufacture of ferrous materials. The editing and referencing of source data is up to the high standards of the previous books in this series. Mr. Comstock, formerly assistant director of research, Titanium Alloy Manufacturing Division, National Lead Company, is one of the major researchers in this field and eminently well qualified to assemble material of meaningful importance. This volume, like the previous books in the Alloy of Iron Monograph series, should be included in every modern metallurgical library.

[1] Assistant Manager of Market Development, Titanium Metals Corporation of America, New York, N. Y.

Titanium in Industry: Technology of Structural Titanium. By Stanley Abkowitz, John J. Burke, and Ralph H. Hiltz, Jr., D. Van Nostrand and Co., Inc., New York, N. Y., 1955. Cloth, $5^3/_4 \times 9$ in., figs., tables, index, x and 224 pp., $5.

One of the major problems of the progressive executive, design engineer, production engineer, or metallurgist in the metals-working or metals-utilizing industries today is familiarizing himself with the newest of man's structural materials—metallic titanium and titanium-base alloys. For it is only after a study that carries the investigator beyond the level of clichés and generalities can titanium's potentialities and limitations be understood. Unfortunately, the investigator can be overwhelmed by the amount of material available to him. Titanium, in its short and still embryo development, has nucleated an avalanche of published work, some good, much not worth the reader's time. Without some background in titanium, particularly for those who are other than research metallurgists, it is difficult to sort the wheat from the chaff.

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The authors, who have been associated with several phases of titanium development at Watertown Arsenal, have attempted to do this sorting for the reader. For the investigator, who has had no previous experience in the challenging and fascinating field of titanium research, production, or fabrication, this book will be of value.

The authors have attempted to provide basic information in the several major areas of titanium. They discuss the industry; production processes; basic physical metallurgy; chemical analysis; fabrication and application. Even with the short history of titanium metal, any one of these subjects would justify a separate publication if it were to be of any more than temporary value. Nevertheless, the authors have done a commendable job of writing, in clearly understandable terms, about the basic considerations in each of these areas. The authors have drawn heavily on the producers' literature and articles appearing in the technical press. As such, this publication will provide a plane of refer-

ence from which the sophisticated reader will want to make a more thorough study of his particular field of interest. For the engineer or technician, who has more than a surface knowledge of titanium, this book will be of limited value. Only in the discussions of chemical analysis and metallography have the authors prepared a text that can be considered as permanent reference data. For the reader with no knowledge of titanium metal, the book will prove interesting and quite readable.

Books Received in Library...

Aciers Inoxydables—Aciers Réfractaires. By L. Colombier and J. Hochman. 1955, Dunod, Paris, France. 526 p., $6^1/_2 \times 9^3/_4$ in., bound. 4750 Fr. Part 1 on corrosion-resistant steels deals with composition, general properties, influence of alloying elements, test methods, and the effects of specific corrosive agents. Part 2 on heat-resistant steels covers both chemical and mechanical resistance at high temperatures and in various atmospheres and discusses particular uses—for valves, etc. Part 3 deals briefly with methods of working and forming these steels.

Air Conditioning, Refrigerating Data Book. Applications Volume. American Society of Refrigerating Engineers, New York, N. Y., fifth edition, 1955. Various paging, $9^3/_8 \times 6^1/_2$ in., bound. $7.50. Sixty-one chapters on the art and science of refrigeration are grouped in eight divisions covering frozen foods; food industries; warehouse practice; food distribution; low-temperature applications; industrial applications; comfort air conditioning; and industrial air conditioning. The chapters on fishing boats, precooling, and passenger automobiles are new, and a number of chapters have been extensively revised.

America's Needs and Resources: A New Survey. By J. Frederic Dewhurst and Associates. Twentieth Century Fund, New York, N. Y., 1955. 1148 p., $10^1/_4 \times 6^1/_4$ in., bound. $10. This encyclopedic survey of the past achievements, present status, and future possibilities of the American economy is some fifty per cent greater in length than its predecessor of the same title published in 1947. Its twenty-six chapters give statistical and analytical information on consumption goods and services, capital requirements, government expenditures, foreign trade, the labor force, natural resources, and productive capacity. Special attention is given throughout to the impact of new products and techniques, and two chapters are devoted to technological change and its effect on productivity.

Basic Engineering Sciences. Revised edition, 100 p., $11 \times 8^1/_2$ in., paper. $3. Problems and Solutions—New York State Professional Engineering Examinations, Parts 2 and 3. 1950 through 1954. 105 p., $11 \times 8^1/_2$ in., paper. $2.25. By Carlos E. Harrington, Springville, N. Y. The first of these booklets for engineers preparing for New York State examinations contains a brief review of fundamentals and answers to 195 questions asked in previous examinations. The second contains 219 problems in economics and practice, hydraulics, machine design, thermodynamics and hygrometry, taken from examinations, 1950 to 1954.

Basic Lubrication Practice. By Allen F. Brewer. Reinhold Publishing Corporation, New York, N. Y., 1955. 286 p., $9^1/_4 \times 6$ in., bound. $6.75. Practical methods for lubricating machine parts, mechanisms, steam turbines, internal-combustion engines, electric motors, and other types of machinery are discussed as an aid to engineers and others concerned with the selection and use of effective lubricants. Automatic lubrication, operating conditions affecting lubrication, physical tests, storage, handling, and reconditioning are also treated, and nonpetroleum lubricants are considered briefly.

Control of Quality in the Production of Wrought Non-Ferrous Metals and Alloys. Part 2: The Control of Quality in Working Operations. (Monograph and Report Series, No. 16.) Institute of Metals, London, England, 1954. 87 p., $11^1/_4 \times 8^3/_4$ in., bound. $2.50. The five papers presented cover the following topics: Control of dimension, shape, and finish in rolling of sheet and strip and in the drawing of wire; control of quality in the hot and cold-rolling of aluminum and aluminum alloys; control of properties and structures in hot and cold-rolling of copper and copper-base alloys; factors affecting the quality of extrusions; and statistical control in metalworking operations. Name and subject indexes are included.

Engineering Mechanics. By Archie Higdon and William B. Stiles. Prentice-Hall, Inc., New York, N. Y., second edition, 1955. 585 p., $9^1/_4 \times 6^1/_4$ in., bound. $7.95. This comprehensive treatment of the usual topics in engineering mechanics features maximum use of the free-body diagram approach and emphasizes the principles employed in the solution of problems. In this edition a number of chapters have been reorganized, a chapter on the use of virtual work in equilibrium has been added, and about forty per cent of the problems have been replaced.

Le Frottement et L'Usure des Metaux—Les Anti-Frictions. By R. Cazaud. Dunod, Paris, France, 1955. 221 p., $9^5/_8 \times 6^1/_2$ in., bound. 2250 Fr. This book presents a general treatment of the mechanics of friction and wear of metals, a discussion of the basic properties of antifriction alloys, and separate chapters on the metallurgical characteristics of the important alloys classified by the base metal. Sintered metals, electrolytic deposits, and special linings are also considered. The emphasis throughout is on use in bearings.

Grinding of Steel. By Eric N. Simons. Odhams Press, Limited, London, England, 1954. 224 p., 6×9 in., bound. 25s. An introduction to industrial grinding practices covering basic factors, practical techniques, finishing processes, and grinding machines. Specific topics dealt with include abrasives; cylindrical, internal, planetary, and other types of grinding; and the grinding of tools and machine parts.

Hydraulic Pumping. A Patent and Literature Survey of Hydraulic Pumping of Oil Wells. By Emory N. Kemler, 1955, published by Summary Reports, P.O. Box 176, Spring Park, Minn. 286 p., $6^3/_4 \times 9$ in., bound. $15. Summaries are given of over 270 patents relating to bottom-hole hydraulic-pump-motor units, 80 patents on hydraulic surface units, and 40 patents on electrically driven bottom-hole pumps. One claim and a brief statement of the purpose of the invention are given for each patent listed, and a large number of drawings are reproduced. An index to inventors, a short bibliography, and a brief introductory section on pumping systems are included.

Journées de Méchanique des Fluides. (Colloques du Centre National de la Recherche Scientifique, No. 1.) France, Ministère de l'Air, Publications Scientifiques et Techniques No. 296, Paris, France, 1955. 330 p., $10^5/_8 \times 7$ in., bound. 3000 Fr. A symposium on fluid mechanics which presents six original research papers on various aspects of the subject—turbulence, flow around airfoils, etc.—and twelve descriptive papers on the equipment and research activities of several of the major French hydraulic laboratories.

Kinematics of Vorticity. By C. Truesdell. (Indiana University Publications, Science Series No. 19.) 1954, Indiana University Press, Bloomington, Indiana. 232 p., $6^3/_4 \times 10$ in., paper. $6. A detailed mathematical analysis of the kinematics of rotational motions of fluids, with a considerable introductory section on geometric and kinematic fundamentals. An extensive bibliography provides a historical framework for the subject as well as specific references for included topics or operations.

Manganese. (Metallurgy of the Rarer Metals, Volume 3.) By A. H. Sully. Academic Press, Inc., New York, N. Y., 1955. 305 p., $6^3/_4 \times 5^1/_2$ in., bound. $6.50. A comprehensive summary of existing knowledge of the metal and its alloys and of its commercial utilization, covering occurrence and classification of ores, production methods, recovery from slags and low-grade ores, physical properties, workability, and electroplating. References are with each chapter.

Metal-to-Metal Adhesives for the Assembly of Aircraft. Edited by Richard G. Newhall. Western Business Publications, San Francisco, Calif., 1955. 63 p., $11 \times 8^1/_2$ in., paper. $4. A collection of twelve papers presented at a conference at the University of California, Los Angeles, Calif., in September, 1954. Four deal with aspects of sandwich construction, others with extrusion coating, inspection of bonds, preparation of aluminum alloys for bonding, adhesive bonded honeycomb structures, and related subjects.

Motion and Time Study. By Benjamin W. Niebel. Richard D. Irwin, Inc., Homewood, Illinois, 1955. 433 p., $9^1/_4 \times 6$ in., bound. $6. In addition to describing procedures for conducting accepted methods and work-measurement programs, this book discusses in detail the requirements and methods of installation of wage-incentive plans. The book is intended both as a college text and as reference manual for industrial engineers and others interested in techniques for saving materials and labor in any type of business.

Transactions of the Symposium on Computing, Mechanics, Statistics and Partial Differential Equations. (Second Symposium on Applied Mathematics.) Sponsored by the American Mathematical Society and Office of Ordnance Research, U. S. Army. Interscience Publishers, Inc., New York, N. Y., 1955. 216 p., $10^1/_4 \times 7$ in., bound. $5. The eleven papers included deal with recent advances in such fields as operations research, statistics, computing, mechanics, and partial differential equations. Typical topics dealt with include iterative computational methods, the simplest rate theory of pure elasticity, and the stability of mechanical systems. The volume is a reprint from the journal *Communications on Pure and Applied Mathematics.*

ASME NEWS

With Notes on the Engineering Profession

Plans Shape Up for ASME Diamond Jubilee Annual Meeting, November 13–18

Power Show, Technical Sessions, Inspection Trips, and Entertainment Spark Program

Some of the women on the various committees to welcome visitors to the 1955 ASME Diamond Jubilee Annual Meeting are shown in the Presidential Suite of the Congress Hotel, Chicago, Ill. The suite, it is hoped, will be reception and general headquarters for the women during the Annual Meeting, November 13–18. Front row, *left to right*, are: Mrs. Richard Hartenberg, Mrs. Frank P. Lawler, Mrs. Alexander Cowle, Mrs. Karl Otte, Mrs. James N. Wogrum, and Mrs. Robert Bacon. Rear row, *left to right*, are: Mrs. Burgess Jennings, Mrs. Harry C. Boardman, Mrs. David Frank, Mrs. Eugene Bailey, Mrs. William A. Dundas, Mrs. John R. Michel, Mrs. Peter VanderPloeg, and Mrs. Richard Morris.

The American Society of Mechanical Engineers' Diamond Jubilee Annual Meeting will be held this year in Chicago, Ill., at the Congress, Conrad Hilton, and Sheraton-Blackstone Hotels from November 13–18. Special features commemorating ASME's 75th Anniversary have been planned for the six-day event.

Technical Papers and Trips

ASME conferees will hear and discuss more than 300 technical papers at 110 sessions covering a variety of subjects: Aviation, applied mechanics, management, materials handling, oil and gas power, fuels, safety, hydraulics, metals engineering, heat transfer, process industries, production engineering, machine design, petroleum, nuclear engineering, railroad, power, textile, gas-turbine power, wood industries, rubber and plastics, and instruments and regulators.

Three interesting trips have been arranged; namely, the Reuben H. Donnelley Press, the Ridgeland Generating Station of Commonwealth Edison Company, and the Museum of Science and Industry. The latter also will afford an inspection of the German Submarine U-505.

The American Rocket Society, an affiliate of ASME, celebrating its 25th Anniversary this year, is holding its sessions within the ASME meeting.

Chicago Section Host

The Chicago Section of ASME will be hosts to their fellow Society members and have arranged an interesting and diversified program of events for them. A dinner and pageant highlighting ASME milestones from 1880 to the present are listed for Tuesday evening, November 15. At a special Honors Luncheon on Thursday, November 17, the five major joint engineering awards will be conferred. These are: The Hoover Medal, John Fritz Medal, Elmer A. Sperry Award, Henry L. Gantt Memorial Medal, and the Daniel Guggenheim Medal.

The Society's Diamond Jubilee banquet on Thursday evening will highlight the week-long festivities, to be followed by closing sessions on Friday. Retiring president Dr. David W. R. Morgan will be the toastmaster at the banquet.

Power Show

Sidelighting the 75th Anniversary celebration will be the "Exposition of Power and Mechanical Engineering" at the Chicago Coliseum from November 14–18. Under the auspices of ASME, the exposition will feature displays showing the newest developments in equipment, power generation and distribution, automatic control, mechanical-power transmission and utilization . . . . maintenance as well as production equipment designed to lower operating costs and reduce maintenance. A new timely section on Atomic Power will also be featured.

ASME Exhibit at Machine Tool Builders Show

As their contribution to the National Machine Tool Builders Show in Chicago from September 6-16, The American Society of Mechanical Engineers will have a booth featuring items of general interest to the machine-tool industry.

This marks the first time that ASME has had an exhibit at the internationally known show. On the occasion of their 75th Anniversary, the Society will have items commemorating their contribution to the machine-tool industry from 1880 to the present.

The booth will highlight dimensional and other ASME-sponsored standards; technical literature from "On the Art of Cutting Metals," by the late Frederick W. Taylor, one of the pioneers in scientific management and 1906 ASME president, to current publications on ASME's research in cutting metals; and technical programs from the Society's meetings of interest to the machine-tool industry. An ASME publication, *Surface Roughness, Waviness, and Lay*, will be offered at the booth to interested viewers of the exhibit.

The 10-day machine-tool industry's show will be held at the Chicago Amphitheater.

ASME Chicago Power and Mechanical-Engineering Show to Reveal New Trends

New trends in design will be extensively demonstrated at the Chicago Exposition of Power and Mechanical Engineering, to be held in the Chicago Coliseum, November 14 to 18. The exposition will be held under the auspices of The American Society of Mechanical Engineers in conjunction with its Diamond Jubilee Annual Meeting, climaxing the year-long celebration of the Society's 75th year. The Coliseum, near hotels where the meetings will be held, affords excellent display facilities and is easily accessible for frequent visits by members and guests.

Advanced Materials

Most remarkable among trends to be revealed at the exposition will be those based on advanced materials and their uses: More resistant alloys have been developed in ferrous and nonferrous metals; more versatile nonmetallic materials have appeared, notably in plastics and ceramics; there have been many advanced applications in the important fields of sandwich materials and coatings. Much of the advancement in materials will be disclosed through exhibits of equipment incorporating improved methods of fabrication, such as are required to accommodate the tougher properties of the new materials. The effect of these innovations has been to permit many designs to be reorganized basically in terms of higher physical specifications.

Atomic-Power Section

The Atomic-Power Section will be a new feature at the exposition. It has been organized to demonstrate phases of the application of atomic energy to power that are of special interest to mechanical engineers, and in support of the program of technical papers to be offered at the ASME meeting. The atomic-energy section of the meeting program will be contributed by the Nuclear Engineering Division, recently organized by the Society.

Nucleonics engineering has already created many new problems, from the shielding of reactor plants and radioactive materials in transit and in use, to many novel functions, such as reactor operation, disposal of radioactive wastes, and even the machining of "hot" materials—all of which must be observed through electronic eyes and manipulated by prosthetic instruments.

One exhibitor in the Atomic-Power Section will offer an engineering consultation service to manufacturers planning to adapt equipment to nuclear applications. Another will present a résumé indicating the hard core of the fast-spreading atomic-engineering industry. This will show that of about one hundred of the most active, nonspeculative organizations now operating, more than 40 are engaged in mining, while the remainder are about equally divided between the processing of materials; the development of reactor components and supplementary equipment; and applications of atomic power under Atomic Energy Commission projects—submarine, surface, and supersurface—or else are associated in the development work of the four great nuclear-power utility plants that are already in progress somewhere between blueprinting and construction.

A number of exhibitors in other sections of the exposition are also active in the fields of atomic power and radioactive materials applications in manufacturing and in medicine. Several are in the direct line of AEC projects, others in the adaptation of conventional engineering equipment to the needs of atomic-power plants in the way of heat exchange and the storage and transfer of isolated liquids and gases.

Mechanical-Engineering Equipment

Among exhibitors of mechanical-engineering equipment to which space in the Coliseum has been allotted are the manufacturer of an extensive line of packaged boilers and another whose specialty is a quick-firing boiler of a type favored in plants where there is an intermittent demand for high-pressure steam. A third exhibitor has an enviable record in equipping plants for the control of fly ash. A fourth specializes in boiler settings. Space was also allotted recently to the exhibitor of a revolutionary new drafting desk.

Products on view will further include mechanical packing and seals, expansion joints, and molded rubber products in one instance; adjustable pipe hangers and supports in another; a unique method of insulation and corrosion protection for underground piping in a third. Underground and overhead prefabricated piping, for steam and hot water, also for viscous liquids, will be seen, as will a newly engineered system of cable and tubing raceways.

New design and new materials will be found in a line of steam traps in semisteel, cast steel, and forged carbon moly. They have high maximum capacity, but operate on low condensate loads.

Power-Transmission Equipment

Power-transmission equipment will be represented by clutches, couplings, hangers, pillow blocks, speed reducers, speed increasers, variable speed transmissions—variety offered in each class. Motors that solve many critical drive problems will account for variety in that classification. In one instance unusual types of alternating-current motors will be shown in action; the English manufacturer originating them is said to be the world's largest a-c motor producer.

There will be displays of motor maintenance equipment—commutator and armature testing and repair appliances in one instance, mechanical and electrothermal carbons for bearings, seals, and special applications, in another.

Among exhibits of massive equipment will be a car shakeout, such as is used for unloading ore, coal, gravel, sand, grain, chemicals, and other bulk materials. The manufacturer of this equipment has also developed and will show for the first time an electronic level indicating instrument. Housed in a rugged steel probe is a small radio transmitter. The probe is set at the predetermined leveling point and, when material being measured flows to that level, change of pressure on the probe distorts the signal that is being transmitted to the control unit. At that point a warning signal may be set off or telemotored controls put in motion.

Advance registrations are being received by the International Exposition Company, with headquarters at 480 Lexington Avenue, New York 17, N. Y. E. K. Stevens is manager of the exposition.

ASME IRD to Present Two Sessions at ISA Conference

Los Angeles, Calif., will become the world center for instrumentation and automation, September 12–16, when the Instrument Society of America's tenth annual Instrument-Automation Conference and Exhibit is held at the Shrine Exposition Hall and Auditorium.

IRD Program

The Instruments and Regulators Division of The American Society of Mechanical Engineers will present a two-session program. The first session to be held on Monday, September 12, at noon, and the second session, Tuesday, at 2:00 p.m. The program for Monday lists the following papers:

A Survey of Methods of End-Point Analysis, by *M. E. Stickney*, Beckman Instruments, Inc., Fullerton, Calif.[1]

Process Control by End-Point Analysis and Associated Data-Reduction Systems, by *Sibyl M. Rock*, ElectroData Corp., and *Jack Walker*, Consolidated Engineering Corp., Pasadena, Calif. (Paper No. 55—IRD-9)

Automation—Its Effect Upon the Future of the Process Industries, by *Ira C. Bechtold*, consultant, La Habra, Calif.[1]

The list for Tuesday is as follows:

Application of Data-Reduction System to the Control of the Union Oil Refinery at Santa Maria, Calif., by *Clyde L. Caldwell*, Union Oil Co. of Calif., Santa Maria, Calif.[1]

Use of Refractometer Controllers, by *H. R. Harris*, Phillips Petroleum Co., Bartlesville, Okla.[1]

Study of Pneumatic Processes in the Continuous Control of Motion With Compressed Air, Part 2, by *J. L. Shearer*, Massachusetts Institute of Technology (Paper No. 55—IRD-10)

Instrumentation Paces Automation

The theme of the show this year will be "Instrumentation Paces Automation." The topic of instrumentation and automation is timely in that its effects will have such vital impact on labor and management and the economy of the nation.

The conference and exhibit have been designed to be the largest national industry event of its kind ever held in the West. There will be more than 500 manufacturers displaying the latest in instrumentation and automation.

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[1] Preprints not available—see box on page 839.

There will be more than 325 technical and clinical sessions during the five-day conference, planned to attract scientific, technical, and research personnel, in addition to the industrial leaders, from the United States, Germany, Japan, England, Scandanavian countries, and several South American countries.

Authorities in the many fields covered will conduct the sessions. Added to the full program of educational sessions, the new Computer Clinic and Data Handling Workshop are this year receiving special attention.

ASME Applied Mechanics Division Announces 1955 Western Conference Program

The West Coast Committee of the Applied Mechanics Division of The American Society of Mechanical Engineers has completed plans for the 1955 Western Conference. The conference is to be held in conjunction with the American Society of Civil Engineers at the United States Naval Post Graduate School, Monterey, Calif., Sept. 12–13, 1955.

This year's conference will feature a tour of the Engineering School laboratories and a luncheon, as well as four technical sessions.

Registration will be conducted in the Main Engineering Building.

Information about housing accommodations can be obtained by writing to Mrs. Helen Hoxie, Manager, Convention Bureau, Monterey Peninsular Chamber of Commerce, Box 489, Monterey, Calif.

The Monterey Peninsula is a place of beauty. Members attending the conference and their wives and families may wish to take a sightseeing tour of the famous "Seventeen-Mile Drive."

Technical program is as follows:

MONDAY, SEPTEMBER 12

8:30 a.m.

Registration

9:30 a.m.

Session 1

Dynamics of Structures and Mechanisms

Frequency Spectra of Continuous Beams on Many Supports, by *J. W. Miles*, University of California[1]

Correlation of Observed and Computed Structural Vibrations Produced by Ground Motion, by *D. E. Hudson* and *G. W. Housner*, California Institute of Technology[1]

The Analysis of Dynamic Stresses in Aircraft Structures During Landing as Nonstationary Random Processes, by *Y. C. Fung*, California Institute of Technology (55—APM-32)

Fourier Analysis of Dynamic Unbalance of the Crank and Connecting-Rod Reciprocating Engine by Contour Integration, by *W. E. Bleick*, U. S. Naval Post Graduate School[2]

1:00 p.m.

Registration

2:00 p.m.

Session 2

Wave Propagation, Yield Conditions

A Study of the Speed of Sound in Porous Granular Media, by *H. Brandt*, California Research Corporation (55—APM-37)

Elastic Stress Waves Produced by Pressure Loads on a Spherical Shell, by *J. H. Huth*, The Rand Corporation, and *J. D. Cole*, California Institute of Technology (55—APM-31)

Yield Conditions for Polycrystalline Materials Loaded Under Constant Deviator of Similitude, by *G. A. Zizicas*, University of California[2]

TUESDAY, SEPTEMBER 13

8:30 a.m.

Registration

9:00 a.m.

Session 3

Nonlinear Dynamics

Steady-State Behavior of Systems Provided With Nonlinear Dynamic Vibration Absorbers, by *F. R. Arnold*, Stanford University (55—APM-30)

Free Oscillations of Systems Having Quadratic Damping and Arbitrary Restoring Forces, by *K. Klotter*, Stanford University (55—APM-34)

Perturbation Methods Applied to Nonlinear Dynamics, by *R. Bellman*, The Rand Corporation (55—APM-33)

12:30 p.m.

Applied Mechanics Luncheon

Reservations must be in by noon of preceding day (Monday, September 12)

2:30 p.m.

Session 4

Elasticity and Plates

The Affine Transformation of Orthotropic Plane-Stress and Plane-Strain Problems,[2] by *H. A. Lang*, The Rand Corporation

A New Approach to the Analysis of Large Deflections of Plates, by *H. M. Berger*, Office of Naval Research (55—APM-36)

Large-Deflection Analysis for a Plate Strip Subjected to Normal Pressure and Heating, by *M. L. Williams*, California Institute of Technology (55—APM-35)

[1] Paper sponsored by ASCE.
[2] Preprints not available—see box on this page.

Preprint Orders

Only preprints of *numbered* ASME papers will be available. Some of these papers may not be available in time to permit your receiving them in advance of the meeting. Your order will be mailed only when the complete order can be filled unless your request that all papers available ten days before the meeting be mailed at that time. Please order only by paper *number;* otherwise the order will be returned. The final listing of available technical papers will be found in the issue of Mechanical Engineering containing an account of the meeting.

Preprints of ASME papers may be obtained by writing to the ASME Order Department, 29 West 39th Street, New York 18, N. Y. Papers are priced at 25 cents each to members; 50 cents to nonmembers. Payment may be made by check, U. S. postage stamps, free coupons, or coupons which may be purchased from the Society. The coupons, in lots of ten, are $2 for members; $4 for nonmembers.

Preprints of unnumbered papers listed by title only in the tentative program *are not available* because the review of these manuscripts had not been completed when the program went to press. The author's name and preprint number will appear with the paper title in the final program (final program available only at meeting) as well as the issue of Mechanical Engineering containing an account of the meeting, if the paper is recommended for preprinting.

ASME Lubrication Conference Plans Completed

The ASME Lubrication Activity of The American Society of Mechanical Engineers and the American Society of Lubrication Engineers have completed plans for the second annual Lubrication Conference to be held Oct. 10–12, 1955, at the Hotel Antlers, Indianapolis, Ind.

It is anticipated that the attendance will surpass the attendance at the Baltimore Conference last year and it is, therefore, suggested that those interested make their reservations early by writing directly to the Hotel Antlers.

The subject of lubrication research and development will be covered by 25 papers presented in succession. The technical program is as follows:

MONDAY, OCTOBER 10

8:00 a.m.

Registration

10:00 a.m.

Session 1

Instability in Journal Bearings

Chairman: *B. L. Newkirk*, consulting engineer, Schenectady, N. Y.
Vice-Chairman: *Stanley Abramovitz*, The Franklin Institute Laboratories for Research and Development, Philadelphia, Pa.

Varieties of Shaft Disturbances Due to Fluid Films in Journal Bearings, by *B. L. Newkirk*, consulting engineer, Schenectady, N. Y.

Experimental and Theoretical Investigation of Half-Running Frequency Whirl, by *B. Sternlicht*, General Electric Co., Schenectady, N. Y.

Experimental Investigation of Resonant Whip, by *Oscar Pinkus*, General Electric Co., West Lynn, Mass.

2:00 p.m.

Session 2

Recent Studies in Hydrodynamic Lubrication, Part 1

Chairman: *John Boyd*, Westinghouse Electric Corp., East Pittsburgh, Pa.
Vice-Chairman: *E. R. Booser*, General Electric Co., West Lynn, Mass.

Journal-Bearing Operation at Superlaminar Speeds, by *M. I. Smith* and *D. D. Fuller*, Columbia University

Analytical Study of Journal-Bearing Performance Under Variable Load, by *G. S. A. Schwaki*, Cairo University, Cairo, Egypt

Journal-Bearing Performance for Combination of Steady, Fundamental, and Low-Amplitude Harmonic Components of Lead, by *G. S. A. Schwaki*, Cairo University, Cairo, Egypt

Studies in Lubrication, XI, by *A. C. S. Ying*, *H. Charnes*, and *E. Saibel*, Carnegie Institute of Technology

Temperature Effects in Hydrostatic Thrust-Bearing Lubrication, by *W. S. Hughes* and *J. F. Osterle*, Carnegie Institute of Technology

The Rheostatic Thrust Bearing, by *J. F. Osterle* and *E. Saibel*, Carnegie Institute of Technology

TUESDAY, OCTOBER 11

Registration

8:00 a.m.

Session 3

Lubricants

Chairman: *L. C. Brunstrum*, Standard Oil Co. of Indiana, Whiting, Ind.
Vice-Chairman: *S. R. Calish, Jr.*, California Research Corp., Richmond, Calif.

Density-Temperature-Pressure Relations for Liquid Lubricants, by *H. A. Hartung*, Atlantic Refining Co., Philadelphia, Pa.

Prediction of the Viscosity of Liquid Lubricants Under Pressure, by *H. A. Hartung*, Atlantic Refining Co., Philadelphia, Pa.

Physical-Chemical Study of Engine-Oil Performance, by *A. Bondi, S. J. Beaubien*, and *H. Diamond*, Shell Development Co., Emeryville, Calif.

Determining Grease Consistency With an Automatic Worker-Viscometer, by *H. J. Connor*, Westinghouse Research Laboratories, East Pittsburgh, Pa.

The Effects of Pressure and Temperature on the Viscosity of Lubricants: Part 2, Applications of Vogel's Equation, by *E. B. Dow*, Navy Bureau of Ordnance, Arlington, Va.

Studies of Formation and Behavior of an Extreme Pressure Film, by *V. M. Borsoff*, Shell Development Co., Emeryville, Calif.

2:00 p.m.

Session 4

Recent Studies in Hydrodynamic Lubrication, Part 2

Chairman: *F. W. Ocvirk*, Cornell University
Vice-Chairman: *E. R. Booser*, General Electric Co., West Lynn, Mass.

Analysis of Elliptical Bearings, by *Oscar Pinkus*, General Electric Co., West Lynn, Mass.

Finite Journal Bearings With Arbitrary Position of Source, by *J. D. Fedor*, Lehigh University

Predicting Performance of Starved Bearings, by *D. F. Wilcock*, General Electric Co., Schenectady, N. Y.

Short Journal-Bearing Hydrodynamic Performance Under Conditions Approaching Zero Minimum Oil-Film Thickness, by *L. F. Kreisle*, Cornell University

Analysis of Partial Journal Bearings Under Steady Loads, by *J. C. Lee*, Armour Research Foundation, Chicago, Ill.

WEDNESDAY, OCTOBER 12

8:00 a.m.

Registration

9:00 a.m.

Session 5

Rolling-Element Bearings

Chairman: *Thomas Barish*, consulting engineer
Vice-Chairman: *E. E. Bisson*, NACA Lewis Flight Propulsion Laboratory, Cleveland, Ohio

Operating Characteristics of High-Speed Ball Bearings at High Oil-Flow Rates, by *C. C. Moore* and *F. C. Jones*, Thomson Laboratory, General Electric Co., West Lynn, Mass.

Effect of Combustion-Resistance Hydraulic Fluids on Ball-Bearing Fatigue Life, by *H. V. Cordiano, E. P. Cochran, Jr.*, and *R. J. Wolfe*, Material Laboratory, New York Naval Shipyard, Brooklyn, N. Y.

Effect of Oxygen Concentration on Atmosphere on Oil Lubrication of High-Temperature Ball Bearings, by *Z. N. Nemeth* and *W. J. Anderson*, NACA Lewis Flight Propulsion Laboratory, Cleveland, Ohio

High-Temperature Bearing Operation in the Absence of Liquid Lubricants, by *S. S. Sorem* and *A. G. Cattaneo*, Shell Development Co., Emeryville, Calif.

2:00 p.m.

Session 6

Boundary Lubrication

Chairman: *W. P. Campbell*, Brush Laboratories, Cleveland, Ohio
Vice-Chairman: *E. Rabinowicz*, Massachusetts Institute of Technology

Lubrication of Friction Drives, by *T. B. Lane*, Thornton Research Center, Shell Research, Ltd., England

Thermal Aspects of Galling of Dry Metallic Surfaces in Sliding Contact, by *F. F. Ling* and *E. Saibel*, Carnegie Institute of Technology

Friction and Wear of Several Metals Lubricated by Difluorodichloromethane and Similar Gases, by *S. F. Murray, R. L. Johnson*, and *M. A. Swikert*, NACA Lewis Flight Propulsion Laboratories, Cleveland, Ohio

AIME-ASME Joint Solid Fuels Conference Program Announced for October 19–21

The Coal Division of the American Institute of Mining and Metallurgical Engineers and the Fuels Division of The American Society of Mechanical Engineers will present the following program at the eighteenth annual joint Solid Fuels Conference which is to be held at the Neil House, in Columbus, Ohio, October 19 through 21.

WEDNESDAY, OCTOBER 19

8:30 a.m.

Registration

10:00 a.m.

Technical Session

Coal Reserves of The United States for Future Use, by *Clayton G. Ball*, Paul Weir Company, Chicago, Ill.[1]

Petrographic Methods for Application to Solid Fuels of the Future, by *James M. Schopf*, Coal Geology Laboratory, U. S. Geological Survey, Columbus, Ohio[1]

The Relation of Petrographic Structure to Utilization of Solid Fuels of the Future, by *Aureal T. Cross*, West Virginia Geological Survey, and *Norman Schapiro*, West Virginia University, Morgantown, W. Va.[1]

12:30 p.m.

Luncheon Meeting

Speaker: *David R. Mitchell*, secretary, Coal Division, AIME
Subject: **The AIME Coal Division, What It Is and What It Does**

Speaker: *Carroll F. Hardy*, chairman, Fuels Division, ASME
Subject: **A Look at the ASME Fuels Division**

2:00 p.m.

Technical Session

The Need and the Opportunities for Fuel Techniques in the Coal Industry, by *T. S. Spicer*, Pennsylvania State University (Paper No. 55—FU-2)

Future Trends in Stoker Design, by *Earle C. Miller*, Riley Stoker Corp., Worcester, Mass. (Paper No. 55—FU-1)

Trends in Coal Handling for Electric-Power Stations, illustrated with a motion picture "From Mine to Plant," by *Howard E. Nelson*, The Jeffrey Manufacturing Co., Columbus, Ohio[1]

6:30 p.m.

Cocktail Hour

7:00 p.m.

Banquet

Toastmaster: *Elmer R. Kaiser*, director of research, American Society of Heating and Air-Conditioning Engineers, Cleveland, Ohio
Songs: Ohio State University Men's Glee Club, directed by Norman Staiger
Speaker: *L. C. Campbell*, president, National Coal Association, Washington, D. C.
Subject: **Coal—Our National Heritage**

THURSDAY, OCTOBER 20

8:30 a.m.

Registration

9:30 a.m.

Technical Session

Coal Preparation at J & L Vesta Mines Showing Trend of Future Coal Washers, by *J. A. Glunt*, Cleveland Steel Works, and *J. R. Dawson*, Vesta-Shanopin Coal Division, Jones & Laughlin Steel Corp.[1]

Solid Fuels and the Dwight-Lloyd Sintering Process, by *Harold E. Rowan*, Dwight-Lloyd Division, McDowell Company, Inc., Cleveland, Ohio[1]

Pulverizing Lignite in a Bowl Mill, by *R. C. Ellman*, Preparation Section, Charles R. Robertson Lignite Research Laboratory, U. S. Bureau of Mines, Grand Forks, N. Dak.[1]

High-Moisture Lignite as a Future Fuel for Steam Generation, by *R. L. Sutherland*, Truax-Traer Coal Co., Chicago, Ill.[1]

12:30 p.m.

Percy Nicholls Luncheon Meeting

Presentation of Percy Nicholls Award for 1955
Recipient: *Ralph M. Hardgrove*
Presenter: *Elmer R. Kaiser*
Speaker: *Ralph A. Sherman*, Battelle Memorial Institute
Subject: **A Man and His Work**

2:00 p.m.

Technical Session

Future of Synthetic Liquid and Gaseous Fuels, by *H. R. Batchelder* and *Harlan W. Nelson*, Fuels Technology Division, Battelle Memorial Institute, Columbus, Ohio[1]

Effect of Fly-Ash Utilization on the Future of Solid Fuels, by *H. H. Russell*, Bituminous Coal Research, Inc., Pittsburgh, Pa.[1]

Navy Policy of Designing for Dual Fuel Firing in Shore-Station Steam-Plants, by *Leroy F. Deming*, Power Generating Section, Bureau of Yards and Docks, U. S. Navy[1]

WOMEN'S PROGRAM

October 19—	8:00 a.m.	Registration, Neil House, Ladies Headquarters, Parlor 1, Mezzanine
	10:00 a.m.	Coffee Hour, Neil House
	12:00 p.m.	Luncheon and bridge at Scioto Country Club
	6:30 p.m.	Cocktail Hour, Neil House
	7:00 p.m.	Banquet, Neil House
October 20—	1:00 p.m.	Luncheon at Maramor Restaurant
	2:30 p.m.	Conducted tour of Columbus Art Gallery

Ladies are cordially invited to attend the Conference. Hostesses will be on the Mezzanine of the Neil House at all times for information on shopping or on points of interest in Columbus.

Authors' Breakfasts

The authors' breakfasts will be held at 8:00 a.m. on October 19 and 20 in Parlor 3 of the Neil House.

Coffee Breaks

Thanks to Trans World Airlines, coffee will be served at both morning technical sessions by TWA hostesses.

[1] Preprints not available—see box on page 839.

Colonel Urwick Receives Wallace Clark Medal

Colonel Lyndall Urwick, Mem. ASME, eminent British management authority, received the coveted Wallace Clark Medal "for his distinguished contribution to scientific management in the international field," during a luncheon at the Hotel Roosevelt, May 24.

The medal, presented annually under the

auspices of Council for International Progress in Management was presented by Prof. Erwin H. Schell, Mem. ASME, of the School of Industrial Management, the Massachusetts Institute of Technology and chairman of the Award Committee.

One hundred top industrial-management leaders attended the luncheon proceedings and heard Colonel Urwick discuss the role that scientific management is playing in free-nation economic recuperation at a time when his own country is making great strides toward "a robust and healthful productivity period."

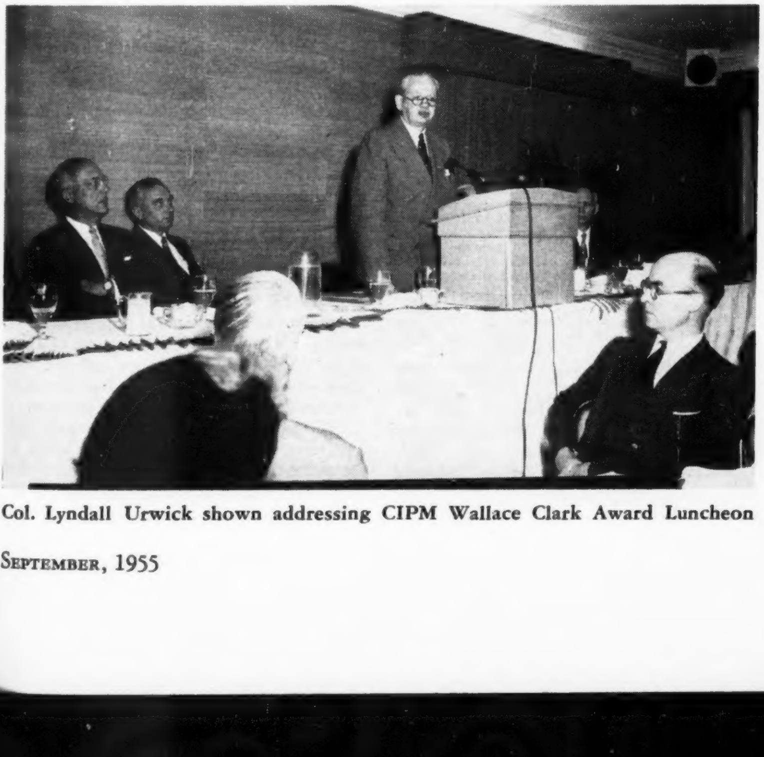
Conceived in 1948 by the Society for the Advancement of Management when Lillian M. Gilbreth, Hon. Mem. ASME, was its chairman, the Wallace Clark Medal was first awarded in 1949 to Hugo de Haan of Geneva, Switzerland, executive secretary of Comité International de l'Organisation Scientifique (CIOS).

The medal has been awarded annually thereafter for "distinguished contribution to scientific management in the international field with no restriction on account of nationality or sex." Trusteeship for the award lies in the hands of the CIPM with its following member organizations as sponsoring bodies: The American Society of Mechanical Engineers, American Management Association, The Society for the Advancement of Management, and the Association of Consulting Management Engineers.

In selecting Colonel Urwick as top international management man of the year Col. P. Garey, vice-president, Operations CIPM, stated, "CIPM and its sponsoring bodies are duly commemorating the outstanding professional achievements in management, and the great service to the cause of scientific management in the international field rendered by Wallace Clark, management engineer and a co-pioneer and leader in industrial management."

With its prime target that of "abolishing Communistic influence in free-world economy," the Council was chosen by the Foreign Operations Administration as the recruiting vehicle charged with the responsibility of selecting teams of United States industrial managers to go abroad to exchange ideas and methods with foreign business leaders for the mutual benefit of free-world industry. Pegging their campaign to "Higher Standards of Living" their now four-year-old effort has brought about radical productivity changes in Great Britain, The Netherlands, West Germany, France, Italy, Denmark, Belgium, Norway, and Turkey. Specific cases of how these American teams have aided their foreign counterparts in the areas of production, marketing, selling, public relations, and human relations are a matter of record.

Among those present at the luncheon were Lawrence A. Appley, Mem. ASME, president, American Management Association; Horace G. Crockett, president, Association of Consulting Management Engineers and partner of McKinsey & Company; Joseph Pope, director, The American Society of Mechanical Engineers and senior vice-president of the Stone & Webster Engineering Company; A. M. Lederer, chairman of the Council for International Progress in Management and partner in Morris and Van Wormer; George Estes, president of the Society for the Advancement of Management and chief of Industrial Engineering of Republic Aviation Corporation.



Col. Lyndall Urwick shown addressing CIPM Wallace Clark Award Luncheon

ASME to Participate in Fifth Plenary World Power Conference, in Vienna, 1956

Atomic-energy development and prospects to be discussed; most of 45 member nations to take part; 2000 attendance expected

United States engineers, scientists, industrialists, and government representatives will present 25 papers on the development of atomic energy, steam and gas turbines, and related subjects of power and fuel technology at the fifth plenary meeting of the World Power Conference in Vienna, June 17–23, 1956, according to Gail A. Hathaway, chairman of the United States National Committee.

ASME Participates Through U. S. National Committee

Constituting the U. S. National Committee are the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, The American Society of Mechanical Engineers, American Institute of Electrical Engineers, American Institute of Chemical Engineers, American Gas Association, Association of Edison Illuminating Companies, and Edison Electric Institute. The U. S. Atomic Energy Commission, Bureau of Mines, Bureau of Reclamation, Corps of Engineers, Federal Power Commission, and Rural Electrification Administration are the U. S. government agencies which also constitute the U. S. National Committee.

Most of the 45 member nations are expected to participate. The general theme will be "World Energy Resources in the Light of Recent Technical and Economic Developments." Representatives of several of these agencies will present papers.

Austria Host to Conference

Austria, host country, is preparing for an attendance of 2000. The Austrian Government plans to invite all nations with which it has diplomatic relations to be represented at the conference by official designees. Similar invitations will be extended to intergovernmental and nongovernmental international organizations by the Austrian National Committee, which is headed currently by Franz Holzinger.

Plenary meetings of World Power Conference are held every six years. Interim sessions, referred to as Sectional meetings, are scheduled regionally at two-year intervals.

Unprecedented interest is being shown in the forthcoming full meeting by government and nongovernment agencies, societies, companies, and individuals in view of the tremendous advances since the last plenary session in 1950 in the fields in which WPC is active, and in view, further, of the great field of development ahead. Water, oil, coal, and atomic power will be among the topics discussed in the United States contributions to the Vienna program.

This country's participation details are being arranged at the headquarters of the U. S. National Committee at 29 West 39th Street, New York, N. Y.

G. A. Hathaway, Chairman

Gail A. Hathaway, chairman of this Committee, is past-president of the American Society of Civil Engineers. He is vice-president of the International Executive Council of the World Power Conference and is also president of the International Commission on Large Dams. Mr. Hathaway, whose home is in Hyattsville, Md., is Special Assistant to the Chief of Engineers, U. S. Army. He is an internationally recognized authority on large dams, hydro developments, and related fields. Stuart M. Crocker of New York, chairman of the board of Columbia Gas System Inc., is vice-chairman of the U. S. National Committee. Brig. Gen. Stewart E. Reimel (ret.), Mem. ASME, is secretary. Sir Harold Hartley is president of the World Power Conference, which has headquarters in London, England.

Members of WPC

Member nations of the World Power Conference are: Algeria, Argentina, Australia, Austria, Belgium, Brazil, Canada, Ceylon, Chile, Czechoslovakia, Denmark, Egypt, Finland, France, German Federal Republic, Great Britain, Greece, Hungary, Iceland, India, Indonesia, Ireland, Israel, Italy, Japan, Luxembourg, Mexico, The Netherlands, New Zealand, Norway, Pakistan, Paraguay, Poland, Portugal, Russia, Spain, Sweden, Switzerland, Thailand, Turkey, United States, Union of South Africa, Uruguay, Yugoslavia, and Venezuela.

WPC Data

World Power Conference was organized "to consider how the sources of heat and power may be adjusted nationally and internationally."

This objective is sought "by considering the potential resources of each country in hydroelectric power, coal, oil, and other fuels and minerals; by comparing experiences in the development of scientific agriculture, irrigation, and transportation by land, air, and water; by conferences of engineers, technical and fuel experts, and authorities on scientific and industrial research; by consultations of consumers of fuel and power and the manufacturers of the instruments of production of power; by conferences on technical education to review the educational methods in different countries, and to consider means by which existing facilities may be improved; by discussions of the financial and economic aspects of industry, nationally and internationally; by conferences on the possibility of establishing a permanent World Bureau for collection of data, preparation of inventories of the world's resources, and the exchange of industrial and scientific information through appointed representatives in the various countries."

The Program in Vienna

"Despite the great variety of subjects, the Vienna program has been drawn up so that the Conference will be able to survey comprehensively the principal trends in the development of the production and uses of energy," said Mr. Hathaway in detailing the scope of the event. "Thus the Conference will be able to realize its purpose of a better understanding among the experts of the nations.

"As everyone knows, recent years have brought forward extraordinary advances in exploiting the known energy sources and in developing new ones. The papers and discussions at the Conference should stimulate further development of the world's power economy.

"Care has been taken that the program shall have a sufficiently broad scope to accord with the present tendencies toward closer interrelationship in methods of production and uses of power. The Conference will try to present the problems that are of the greatest current general interest. To that end, a free choice is permitted the participant nations in the presentation of subjects within the scheduled divisions and sections of the program."

The General Conference program will be presented in the following divisions:

1 State and development of power production and utilization in individual countries.
2 Preparation and conversion of fuels.
3 Utilization of primary sources of energy.
4 Purification of waste water and waste gas in the production and use of energy.
5 International collaboration in the production and use of energy.

United States Papers

Each of these divisions is divided into sections. The United States papers will include:

Division 1: **Energy Resources of the United States,** by *Ralph L. Brown,* Bureau of Mines

Hydroelectric Power Development in the United States, by *Frank L. Weaver,* chief, Division of River Basins, Bureau of Power, Federal Power Commission, and *George G. Adkins,* hydraulic engineer in the same Bureau

The Determination of the Hydroelectric Energy Resources of a River Basin, by *J. R. Riter,* chief development engineer, Bureau of Reclamation, Denver

Division 2: **Atomic Fuels,** by *Frank Spedding,* director, Ames Laboratory, Iowa State College

The Preparation and Treatment of Liquid Fuels, by *E. B. Reeves,* executive vice-president, Esso Engineering and Research Co., New York, N. Y.

Natural Gas as an Energy Source in the United States, by *George G. Oberfell,* consultant, petroleum and gas industries, Bartlesville, Okla., and *T. W. Legatski,* Phillips Petroleum Co., Bartlesville, Okla.

Economic Requirements for the Establishment and Operation of Long-Distance Gas-Supply Systems, by *Joseph J. Hedrick,* president and general manager, Natural Gas Pipeline Co. of America, Chicago, Ill.

Division 3: **Progress in Steam Turbine-Generator and Gas-Turbine Design From 1950 to 1955 by the General Electric Company,** by *Carl Schabtach,* manager of engineering, large steam turbine-generator department, and *H. D. Kelsey,* manager of engineering, gas-turbine department, both of Schenectady, N. Y.

The Development of the 4500-Psi Multiple Superheat Supercritical Generating Unit for Philo, by *Philip Sporn,* Fellow ASME, president, American Gas and Electric Co., New York, N. Y.

Technical Advances in Steam Turbine-Generator Design, by *J. R. Carlson,* Mem. ASME, manager of engineering, steam division, Westinghouse Electric Corp., South Philadelphia Works, and *A. M. Harrison,* manager of engineering, transportation and generator division, Westinghouse, East Pittsburgh, Pa.

Technical Advances in Steam Turbine-Generator Units, Allis-Chalmers Manufacturing Co., by *C. D. Wilson,* Mem. ASME, engineer in charge, steam-turbine design, and *L. T. Rosenberg,* engineer in charge, synchronous generator design, both of Milwaukee, Wis.

Technical Advances in Steam Boiler Design, The Babcock & Wilcox Company, by *W. H. Rowland,* vice-president, and *George Kessler,* chief engineer, both of New York, N. Y.

American Steam Power, 1950–195[illegible] by *J. N. Landis,* Fellow ASME, vice-presid[illegible], Bechtel Corp., San Francisco, Calif.

Technical Advances in Steam-Generator Design, Combustion Engineering, Inc., by *Otto de Lorenzi,* Fellow ASME, director of education and fuels consultant, Combustion Engineering, Inc., New York, N. Y.

Big Creek Hydro Development, by *James F. Davenport,* vice-president and general manager, Southern California Edison Co., Los Angeles, Calif.

Hydroelectric Power in Multiple-Purpose Water Resource Development Programs, by *Charles W. Kinney,* Corps of Engineers, Washington, D. C.

Status of Nuclear-Power Technology, by *W. Kenneth Davis,* Mem. ASME, director, Division of Reactor Development, Atomic Energy Commission, Washington, D. C.

Economics of Nuclear Power, by *U. M. Staebler,* chief, Civilian Power Reactor Branch, Atomic Energy Commission, Washington, D. C.

The Proposed Consolidated Edison Company of New York Nuclear-Power Plant, by *Gordon R. Milne,* Mem. ASME, mechanical engineer, Consolidated Edison Co. of New York, and *John W. Landis,* director of customer relations, atomic-energy division, The Babcock & Wilcox Co.

Economic Considerations Involved in the First Power Reactor for New England, by *R. Leigh Fitzgerald,* assistant to the president, New England Electric System, Boston, Mass.

A Large Fast Neutron Breeder Reactor Power Plant, by *Walker L. Cisler,* Fellow ASME, president, Detroit Edison Co., and *Arthur S. Griswold,* Mem. ASME, assistant to the president of Detroit Edison.

A 180-Megawatt Boiling-Water Reactor Power Plant, by *Titus G. LeClair,* assistant to vice-president, Commonwealth Edison Co., Chicago, Ill.

Status Report on the Pressurized Water Reactor (PWR) Plant, by *John W. Simpson,* Mem. ASME, assistant division manager, atomic-power division, Westinghouse

Division 4: **Disposal of Atomic Wastes in the Atomic-Energy Industry,** by *Arthur E. Gorman,* chief, Sanitary Engineering Development Branch, reactor development division, AEC, Washington, and *Gordon E. McCallum,* chief, Water-Pollution Control, division of sanitary engineering services, U. S. Public Health Service, Washington, D. C.

Division 5: **Power-Pool Operations,** by *H. L. Melvin,* chief consulting engineer, Ebasco Services, Inc., New York, N. Y.

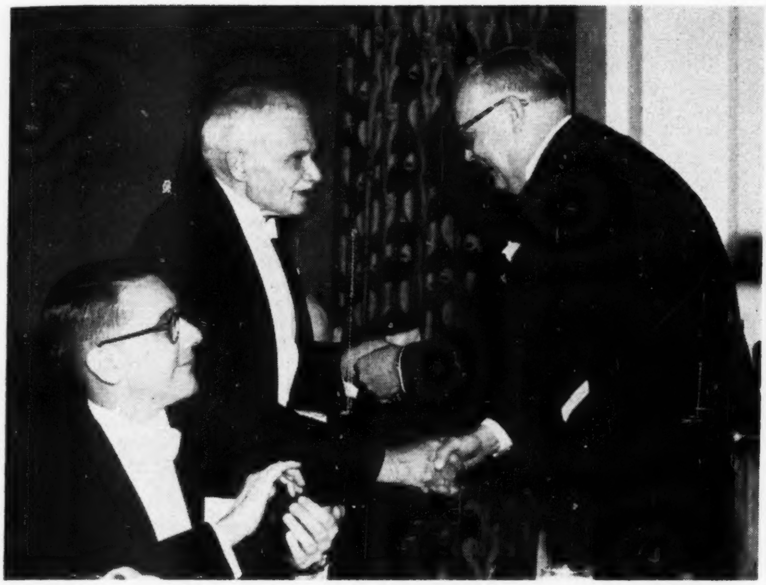
L. F. Grant Honored by ASME

The American Society of Mechanical Engineers, having selected Lt. Col. L. F. Grant, Hon. M.E.I.C., as the recipient of a special medal marking the Society's 75th Anniversary, took the occasion of the EIC annual banquet to make the presentation.

Thompson Chandler, vice-president, expressed the appreciation of ASME to Colonel Grant, the field secretary and a past-president of the Institute, and president of the Engineers' Council for Professional Development. Mr. Chandler spoke as follows:

"President Morgan of The American Society of Mechanical Engineers has asked me to express his regret that an extended Society trip to the Pacific Coast made it impossible to be present this evening and perform this pleasant duty. It is a privilege for me to be here to enjoy your good fellowship and an honor to serve for President Morgan on this occasion.

"This year the ASME is celebrating its 75th Anniversary in a series of events designed to dramatize the 'Engineer in Our World.' Our celebration is extending throughout the year, throughout U. S. A., in Copenhagen, in Brazil,



Colonel L. F. Grant, field secretary, The Engineering Institute of Canada, accepts the 75th Anniversary Medal of The American Society of Mechanical Engineers, in recognition of his outstanding work as chairman of ECPD since 1952, from Thompson Chandler, Vice-President, ASME Region V, during the EIC banquet held May 13 in the Royal York Hotel, Toronto, Ont. F. Kenneth Hare, guest speaker, applauds.

in Mexico, and here tonight in Toronto. The Engineering Institute of Canada has honored our Society by permitting this important element of our celebration to be carried on here. For that courtesy we are grateful.

"During our year of celebration we deem it our duty to recognize the great services rendered to the Society and the profession by leaders from outside our borders particularly those who have successfully headed joint engineering agencies. Tonight, it is my pleasure to bring a special tribute to one who has worked valiantly for the engineering profession on our continent.

"I refer to Colonel Leroy Fraser Grant, your representative for six years on Engineers' Council for Professional Development and now serving his third year as president of that body. In his work on ECPD his qualities of intelligent devotion and farseeing leadership have endeared him to all who have worked with him. He headed with distinction two ECPD delegations to educational conferences in Europe.

"You know of Colonel Grant's successful career in engineering, in education, and in the military service. Your Society, The Engineering Institute of Canada, recognized his qualities by selecting him as president and by making him an honorary member. The Institute with wisdom and forethought selected him as one able to make a great contribution to the work of ECPD and further provided the opportunity for him to participate. It is fitting, therefore, that this recognition be given to him here.

"One of the unique characteristics of the relations between our two nations is the manner in which we share our feelings for great leaders in both nations. We want you to know that we share your affection and respect for Colonel Grant.

"Accordingly, it is a great honor and a distinct pleasure on behalf of the Council and members of The American Society of Mechanical Engineers to bestow a special 75th Anniversary Medal and Certificate on Leroy Fraser Grant 'in appreciation of his devoted service and outstanding leadership in the Engineers' Council for Professional Development and as its President.' "

People . . .

Honors and Awards. The recipients of four of the five major joint engineering awards to be conferred during the ASME Diamond Jubilee Annual Meeting, in Chicago, Ill., November 13–18, have been announced. They are: The Hoover Medal to Charles F. Kettering, Fellow ASME; John Fritz Medal to Philip Sporn, Fellow ASME; Elmer A. Sperry Award to William F. Gibbs, Fellow ASME; Henry L. Gantt Memorial Medal to Walker L. Cisler, Fellow ASME. The recipient of the Daniel Guggenheim Medal is yet to be announced.

Ralph S. Damon, Mem. ASME, president of Trans World Airlines, Inc., has been named the recipient of the ASME Spirit of St. Louis Medal. Mayor Raymond R. Tucker of St. Louis, Mem. ASME, will act as master of ceremonies at a banquet honoring the airline executive, to be held at the Hotel Statler, St. Louis, Mo., September 29.

Stefan L. Grapnel, Mem. ASME, chief engineer, Belding-Hemingway-Corticelli Co., Putnam, Conn., was presented with the 75th Anniversary Award by the New London Section of ASME. He is past-chairman of the Section and presently is serving as delegate to the Connecticut Technical Council and the Connecticut General Committee.

Edward J. Barakauskas, Assoc. Mem. ASME, development engineer for Westinghouse Electric Corporation's Aviation Gas Turbine Division research department in South Philadelphia, Pa., has been awarded the Benjamin Garver Lamme Graduate Scholarship.

Everett P. Partridge, Mem. ASME, director of Hall Laboratories, Inc., Pittsburgh, Pa., was presented the 1955 Max Hecht Award of the American Society for Testing Materials, during the society's 58th annual meeting, in Atlantic City, N. J. At the same meeting it was announced that Richard L. Templin, Mem. ASME, assistant director of research and chief engineer of tests, Aluminum Company of America, New Kensington, Pa., was elected to honorary membership in ASTM.

Major General Albert Boyd, commander of Wright Air Development Center, Dayton, Ohio, was the recipient of the Octave Chanute Award presented by the Institute of the Aeronautical Sciences. Gottfried Guderley, who is also with Wright Air Development Center, was the winner of the Thurman H. Bane Award for 1955. The awards were presented June 23, in Los Angeles during the fifth International Aeronautical Conference sponsored by the IAS and the Royal Aeronautical Society of Great Britain.

Margaret H. Hutchinson of Stone & Webster Engineering Corporation was given the annual award of the Society of Women Engineers for "outstanding achievement in engineering" at the society's award dinner, held June 25, in Hollywood, Calif. Dr. Hutchinson is further distinguished as the first woman to be admitted to the American Institute of Chemical Engineers; she is the only woman holding active membership in that organization; she is the only woman who has received an ScD in chemical engineering from the Massachusetts Institute of Technology; and she, as a full-fledged engineer, holds top responsibility on her company's development and design jobs to which she is assigned. These have included such major plants at home and abroad as units for the volume production of penicillin, huge oil-refinery facilities at Abadan, and units for high production of synthetic rubber.

Charles Allen Thomas, president, Monsanto Chemical Company, St. Louis, Mo., and a leader in the wartime atomic-energy program, will receive the 1955 Priestley Medal, highest honor in American chemistry, at a general assembly in the Coffman Memorial Union, University of Minnesota, Monday night, September 12. The gold medal is conferred annually by the American Chemical Society.

Joseph G. Davidson, vice-president of Union Carbide and Carbon Corporation, New York,

ASME President Morgan, principal speaker at dinner meeting held by Columbia Basin Section to mark Society's 75th Anniversary, is shown with Section officers and award winners. Shown, *left to right,* are L. C. Koke, secretary-treasurer, Columbia Basin Section; E. M. Johnston, 75th Anniversary Medal winner; President Morgan; J. R. Carrell, vice-chairman; M. G. Patrick, chairman; and M. W. Carbon, recipient of a Certificate of Award and past-chairman of the Section.

was assistant chief of the Navy's Bureau of Aeronautics in charge of research and development. He succeeds F. K. Teichmann, Mem. ASME, who has headed the Guggenheim School since 1945. Professor Teichmann will devote full time to his duties as assistant dean in charge of the day division of the College of Engineering.

Louis H. Roddis, Jr., has been appointed deputy director of the Division of Reactor Development and Frank K. Pittman as deputy director of the Division of Licensing by the U. S. Atomic Energy Commission.

Mary F. Blade, first and only woman teacher of engineering at The Cooper Union, has been named director of Cooper Union's 1000-acre Green Engineering Camp at Ringwood, N. J. At the same time, Mrs. Blade was raised from assistant professor to associate professor in the mechanical-engineering department of The Cooper Union School of Engineering.

Visiting Professor. Rudolph Plank, world-famous authority on refrigeration and its applications, will be in residence this fall at Columbia University as visiting professor of mechanical engineering. Dr. Plank has been professor at the Institute of Technology

N. Y., has been chosen to receive the Chemical Industry Medal for 1955 "for conspicuous services to applied chemistry." Formal presentation of the medal will be made at a meeting of the American Section of the Society of Chemical Industry, at the Waldorf-Astoria Hotel, New York, N. Y., Oct. 28, 1955.

William S. Johnston, Mem. ASME, president, Johnston Cadillac, Inc., Trenton, N. J., has been promoted from the rank of Colonel to Brigadier General in the United States Air Force Reserve. General Johnston's promotion is in recognition of more than 30 years of active service in the AFR. His decorations include the Legion of Merit and the Air Force Commendation Medal.

Morehead Patterson, Mem. ASME, chairman of the board and president, American Machine & Foundry Company, has been named "Business Statesman of the Year" and received his award at the National Distribution Congress of the National Sales Executives, held in June at the Waldorf-Astoria Hotel, New York, N. Y.

Appointments. Sydney Goldstein has been appointed Gordon McKay Professor of Applied Mathematics in the Division of Engineering and Applied Physics at Harvard University. Dr. Goldstein is an international leader in research in hydrodynamics and aerodynamics.

Rear Admiral Robert S. Hatcher (Ret.) has been appointed director of the Guggenheim School of Aeronautics at the New York University College of Engineering. He also was named chairman of the department of aeronautical engineering, with the rank of professor. Until his recent retirement after 31 years of active service, Admiral Hatcher

10,000th Degree Conferred: *Left to right,* H. S. Rogers, Mem. ASME, president of the Polytechnic Institute of Brooklyn, confers the school's 10,000th degree at the Institute's 100th annual commencement exercises on Thomas Lockwood Lane, Brooklyn, N. Y., who earned his degree in mechanical engineering from Polytechnic's pioneer degree-granting evening session in seven years. Typical of evening-session men who are employed in industry throughout the metropolitan area, Mr. Lane has worked as a design engineer on marine equipment such as winches and docking carriages for the marine equipment firm of Almon A. Johnson, Inc., New York, N. Y. He left shortly after graduation for Calcutta, India, where he will work on the installation of docking facilities for ocean-going vessels on the staff of an American firm. Mr. Lane entered Polytechnic in 1948. He attended the day session one term in 1952. In World War II, in which he enlisted in 1940 in Canada, he was a Sergeant Major and served in the British Army until March, 1946. Polytechnic's centennial year commencement took place in June.

at Karlsruhe, Germany, where he founded the Refrigeration and Food Preservation Institute. He is the author of many books and papers on thermodynamics, refrigerating engineering, and food preservation. For his work he has received many distinguishing honors, the most recent one, the Kammerling Onnes medal of the Dutch Refrigeration Association. The course Dr. Plank will give at Columbia, in co-operation with Prof. Carl F. Kayan, Mem. ASME, is entitled, "Contemporary Problems of Refrigeration and Food Preservation." It will deal primarily with the analysis of problems concerned in the preservation of foods by refrigeration processes, as associated with cold-storage warehouses, freezing plants, locker systems, and the like.

Society Presidents. Enoch R. Needles, senior partner of Howard, Needles, Tammen & Bergendoff, of New York and Kansas City, has been named by the board of direction of the American Society of Civil Engineers as its nominee for president.

A. O. Schaefer, vice-president in charge of engineering and manufacturing, The Midvale Company, Philadelphia, Pa., will take office October 19, as president of the American Society for Metals.

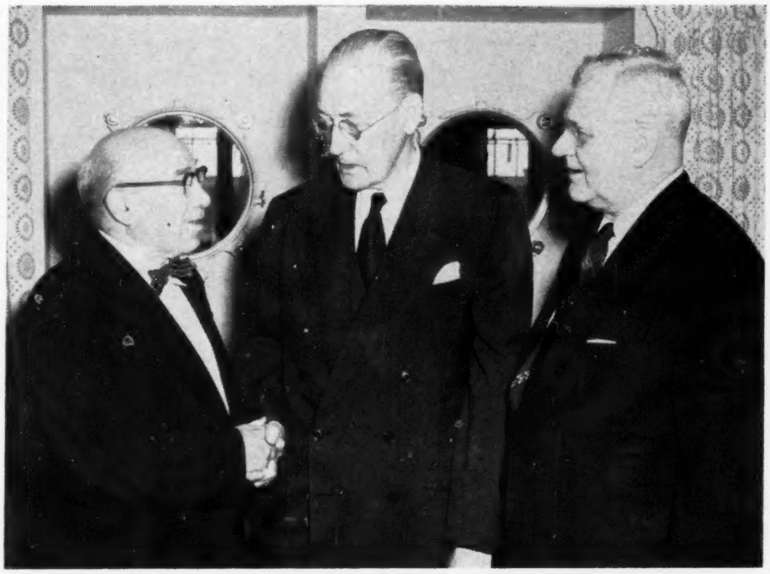
Claire H. Fellows, director, Engineering Laboratory and Research Department, The Detroit Edison Company, Detroit, Mich., has been elected president of the American Society for Testing Materials.

Thomas Rutherford, a director, The Midvale Company, Philadelphia, Pa., was elected president of the Alloy Casting Institute at the close of its 15th annual meeting held in Hot Springs, Va.

J. W. Hopkinson, president of the Penn-Petroleum Corporation, Detroit, Mich., was named the new president of the American Society of Lubrication Engineers.

Allison C. Neff, vice-president of Armco Drainage & Metal Products, Inc., Middletown, Ohio, recently was named the new president of the National Society of Professional Engineers.

The American Management Association announced the election of four divisional vice-presidents. Newly elected officers are as follows: Vice-president in charge of the general management division, Alden G. Roach, president, Columbia-Geneva Steel Division, United States Steel Corporation, San Francisco, Calif.; vice-president in charge of the insurance division, Roy L. Jacobus, manager, insurance department, Ford Motor Company, Dearborn, Mich.; vice-president in charge of the manufacturing division, Robert K. Mueller, vice-president, Plastics Division, Monsanto Chemical Company, Springfield, Mass.; and vice-president in charge of the marketing division, S. T. Harris, Texas Instruments, Inc., Dallas, Texas.



William F. Gibbs, Fellow ASME, *center,* designer of the S.S. *United States,* bids David W. R. Morgan, *left,* ASME President, bon voyage as Dr. Morgan sailed, August 5, to attend the biennial conference of Engineering Societies of Western Europe and the United States. C. E. Davies, secretary of ASME, looks on. On September 6 in Copenhagen Dr. Morgan will present special ASME 75th Anniversary Medals to 14 Western European engineering societies. He will also confer the certificate of Honorary Membership in ASME upon Georg F. C. Dithmer, President of the Institution of Danish Civil Engineers and chairman of the conference. Aboard ship Dr. Morgan will be especially interested in the record-breaking propulsion equipment of the *United States* for it was under his direction, as vice-president in charge of the Westinghouse Steam Division in South Philadelphia, Pa., that the marine turbines, gears, and other propulsion machinery for the vessel were built. The United States Lines recently announced that in the first three years of service the 53,329-ton vessel set a record for performance. During those three years, according to the announcement, "not once have the mighty vessel's shafts been stopped or slowed at sea because of any machinery difficulties."

American Nuclear Society Elects First President

The American Nuclear Society, the world's first professional organization composed of scientists and engineers engaged full time in industrial, governmental, and educational aspects of atomic energy, announced the election of W. H. Zinn as its first president.

The announcement was made at the Society's first annual meeting of the membership at the Pennsylvania State University.

W. H. Zinn, first president of American Nuclear Society

The new organization now has 850 members.

A 30-member board of directors, whose membership includes representatives of every leading atomic-energy establishment in this country, as well as from abroad, was also elected. The foreign members of the board of directors include W. B. Lewis, research director at Canada's Chalk River atomic-energy installation, and Gunnar Randers, Norwegian physicist who is director of the Joint Dutch-Norwegian Nuclear Energy Establishment.

Dr. Zinn, a pioneer in the American atomic program, is director of the U. S. Atomic Energy Commission's Argonne National Laboratory, Lemont, Ill. He is one of the world's foremost authorities on nuclear-reactor design.

Other officers elected by the Society are: Philip Sporn, Fellow ASME, president, American Gas & Electric Company, New York, N. Y., vice-president; Karl Cohen, vice-president, Walter Kidde Nuclear Laboratories, Inc., Garden City, N. Y., treasurer; and J. G. Beckerly, Schlumberger Well Surveying Corporation, Ridgefield, Conn., editor.

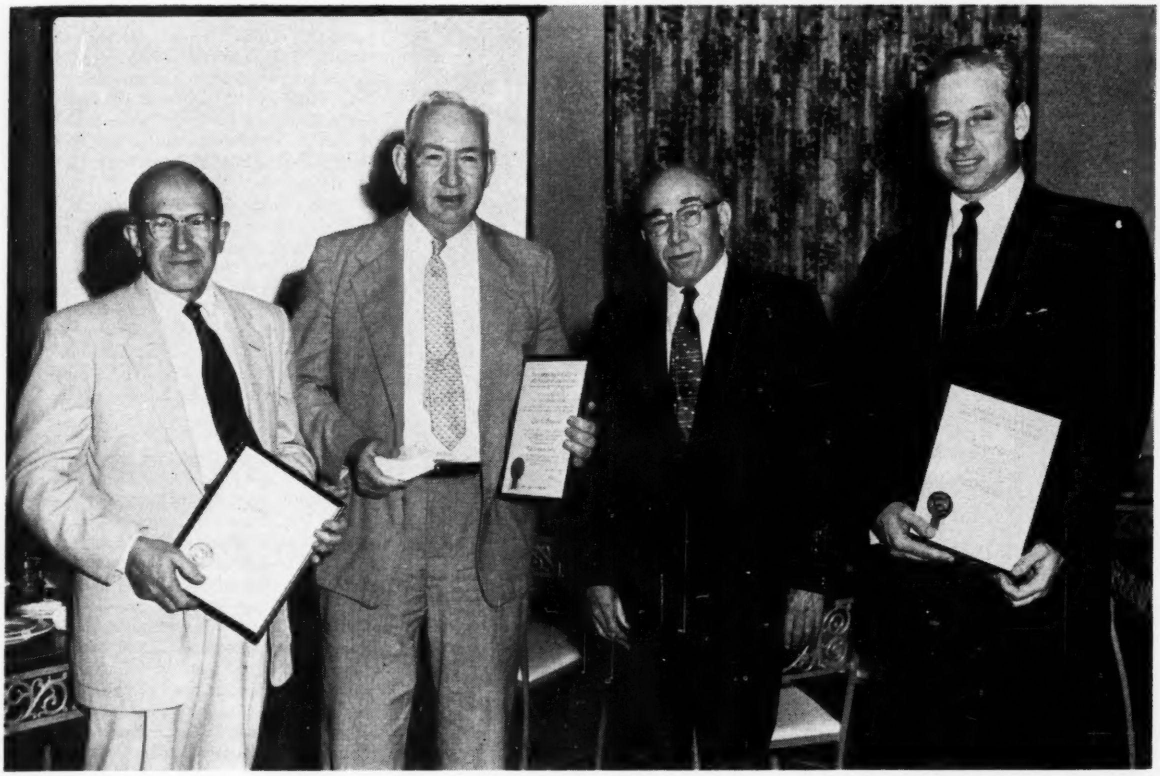
Correction

In last month's report of Honorary Memberships conferred at the 1955 ASME Semi-Annual Meeting the note "deceased since election" erroneously appeared after the citation of Richard Edgar Heartz.—Editor.

Mexico Section. Members and distinguished guests of the Mexico Section of The American Society of Mechanical Engineers attended a dinner and special session to commemorate the 75th Anniversary of the Society at the American Club in Mexico City. Shown in upper photo, *left to right*, are: G. D. Camp, past-chairman of the section; Gustave Maryssael, guest of honor, president of Mexican Light and Power Company, who gave a report on a recent visit to San Francisco, Calif., to attend meetings on industrial uses of atomic energy sponsored jointly by the Atomic Industrial Forum and Stanford Research Institute; J. K. Jennings, chairman of the Mexico Section; Emilio Leonarz, who delivered the lecture at the special session, in which he outlined the history of atomic development and described the operating principles and structural elements of an atomic reactor; G. McLaughlin, vice-chairman, Mexico Section; H. Harleston of the ASME Students Group; J. M. Zilboorg, past-chairman of the Section; and R. Rodriguez, Mem. ASME, manager of Allis-Chalmers de Mexico. In the lower photo is a view of part of the audience who attended the Special Commemorative Session. At a subsequent meeting José María Cabrera, Mem. ASME, prominent authority in the sugar industry, and technical adviser for the Secretaria de Economia, was awarded the 75th Anniversary Medal for "outstanding service to the Mexico Section."

ASME Sections Celebrate . . .
. . . Society's 75th Anniversary

Anthracite-Lehigh Valley Section. Paul B. Eaton, professor-emeritus of mechanical engineering at Lafayette College, received the 75th Anniversary Award of the Society at a meeting of the Section held at the Pocono Manor Inn. James F. Young, Mem. ASME, former student of Professor Eaton, and now a consultant with General Electric Company, made the formal presentation of the medal and citation on behalf of the Society. Mr. Young paid tribute to Professor Eaton both for his work as a teacher and for his activities in the ASME. Prof. W. G. McLean, Vice-President, ASME Region III, presented a gift to Professor and Mrs. Eaton for their new home in Forks Township, Pa. Professor Eaton, who recently returned from Formosa, where he assisted in the technical training of the Chinese, reviewed the history of that island and the work the Chinese Nationalists are doing there. The Chinese on Formosa, he told, are determined to return to the mainland when a national government is established there. He warned that if Formosa is lost to the communists, Okinawa also will be lost and Japan eventually will fall to Russia. E. W. Nelson, of Allentown, chairman of the Section, presided.



Mid-Continent Section. ASME President David W. R. Morgan attended a meeting of the Mid-Continent Section of ASME, at which three of its members were honored. President Morgan made the formal presentation of citations and awards. The three men receiving honors are shown, *left to right*, John H. Keyes, who received the Certificate of Award; Carl Stevens, 75th Anniversary Medal; President Morgan; and R. P. Lennart, Certificate of Award. Mr. Keyes was the chairman of the Mid-Continent Section, 1947–1948. He has been a member of the Executive Committee almost continuously for many years; has served on numerous committees; and is now the vice-chairman in charge of Student Activities. Mr. Stevens has probably done more to further the aims and objectives of ASME than any other member in the Mid-Continent Section. He has been consistently a hard-working member for over 30 years. He is presently chairman of the Section; has been treasurer of the Section; a member of the National Nominating Committee; Chairman of the Finance Committee for the National Petroleum Conference; and Regional Membership Chairman. Mr. Lennart was chairman of the Mid-Continent Section, 1952–1953 and 1953–1954. He has served on the Executive Committee for several years, always taking an active interest in the Society's functions. His leadership coupled with a rare insight into the solution of problems have made him an outstanding member of the Mid-Continent Section.

Wins Student Award. Donald L. Barksdale, *left*, senior petroleum-mechanical-engineering student at Texas A&M College, receives the 75th Anniversary Student Award Medal given by The American Society of Mechanical Engineers, to the outstanding mechanical-engineering student in schools of the nation which have Student Branches of the ASME. C. W. Crawford, Mem. ASME, head of the mechanical-engineering department, makes the presentation. Selection of the outstanding student is made by the department faculty.

A point of interest in New Orleans, La., where the tenth annual ASME Petroleum Mechanical-Engineering Conference will be held, September 26–28, at the Roosevelt Hotel. Shown is a view of Chartres Street looking through the iron grill of the lower Pontalba Apartment balcony. The St. Louis Cathedral, built during the Spanish regime, is in the center. On its left is the Cabildo, where the transfer of the Louisiana Territory from France took place in 1803. On its right is the presbytère, or priest house, which with the cabildo now house the Louisiana State Museum. These buildings face Jackson Square, originally known as the Place d'Armes, and form the heart of Vieux Carre.

Tenth ASME Petroleum Mechanical-Engineering Conference Expected to Be Greatest Ever

The number of reservations made to date at the Roosevelt Hotel, New Orleans, La., for the tenth annual Petroleum Mechanical-Engineering Conference has exceeded all expectations. The Petroleum Division of The American Society of Mechanical Engineers, which is sponsoring this conference in co-operation with the New Orleans Section, has succeeded in scheduling technical papers from many of the outstanding petroleum engineers in the Society covering production, transportation, refining, off-shore drilling operations, and materials. The papers will be presented at 17 technical sessions from September 26th through the 28th.

The New Orleans Section has gone all out to provide excellent entertainment, both in the social affairs and the inspection trips for both the men and women who attend. The program of the tenth conference was published in Mechanical Engineering, on pages 746 and 747, of the August issue.

Two talks will highlight the program. David W. R. Morgan, President, ASME, will address the Welcoming Luncheon on the "Future of Power Generation," which will be held Monday, September 26. H. J. Voorhies, vice-president and general manager of Esso Standard's Louisiana Division, will address the banquet audience, Tuesday evening, on the subject, "Louisiana and Oil."

Both Governor Kennon of Louisiana and Mayor Morrison of New Orleans are giving their whole-hearted support to this conference, thereby assuring all attending an opportunity to learn of and to enjoy Louisiana and New Orleans at their best.

PIB Closes Centennial Year With Small Gas-Turbine Symposium

ASME to Sponsor Meeting

One of the final events of the centennial year celebration at the Polytechnic Institute of Brooklyn will be the presentation of a Small Gas-Turbine Symposium, Saturday, October 1.

Jointly sponsored by the Polytechnic Mechanical-Engineering Department and the Metropolitan Section of The American Society of Mechanical Engineers, the symposium will be held as an all-day and evening session in the auditorium of the Engineering Societies Building, 29 West 39th Street, commencing at 9 a.m.

The Polytechnic Committee for the Symposium includes Profs. Jerome Bartels, Herman Grau, and Clifford A. Wojan of the Department of Mechanical Engineering.

Keynoter for the coming Small Gas-Turbine Symposium will be P. F. Martinuzzi, Mem. ASME, professor of mechanical engineering at the Stevens Institute of Technology, Hoboken, N. J.

Leaders in the field who will speak at the morning session of the symposium include: A. A. Hofar, manager, Product Planning and Marketing Research, Gas Turbine Department, General Electric Company, Schenectady, N. Y., who will talk on gas-turbine cycles; Prof. Clifford A. Wojan, and Wen Wu, research assistant, of Brooklyn Polytechnic, who will discuss Tip-Loss Research, a subject on which Wen Wu is basing his doctoral dissertation.

In the afternoon W. W. Chao, supervisor of the Combustion and Heat Exchangers Section, of the Gas Turbine Department, Scientific Laboratory, Ford Motor Company, Detroit, Mich., will discuss Automotive Gas Turbine Compact Heat Exchangers. At the same session will be Robert O. Fehr, consulting engineer of the General Engineering Laboratories, General Electric Company, on Noise of Gas Turbines; Lloyd E. Berggren, Engine Controls Section of the Minneapolis-Honeywell Regulator Company, on Instruments and Controls; and J. J. Harwood, head of the Metallurgy Branch of the Office of Naval Research, on Metallurgy for High Temperatures.

The three lecturers scheduled for the evening session are: Leo Kingston, senior staff design engineer, Piasecki Helicopter Company, on Dynamic Loading of Transmissions; Henry C. Hill, Boeing Aircraft, Development and Operating Experiences, and A. T. Gregory, Fairchild Engine Company, Development and Operating Experiences.

Hoover Medal Fund

The Hoover Medal Fund has received an anonymous gift of $5000, it was announced jointly on August 4, by Scott Turner, Chairman of the Hoover Medal Board of Award, and Dr. David W. R. Morgan, President of The American Society of Mechanical Engineers, administrators of the Hoover Medal Fund.

The Hoover Medal was established in 1929 through a trust fund established by the gift of Conrad N. Lauer, past-president of ASME, to commemorate the principles and ideas of civic obligations and public service exemplified by the life and work of Herbert Hoover. The medal, "awarded by engineers to fellow engineers for distinguished public service," is administered by the Hoover Medal Board of Award consisting of representatives from ASME, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, and the American Institute of Electrical Engineers.

The first award of the medal was made to Herbert Hoover in 1930. Since then, engineers, leaders of industry, administration, research, and education who have performed some outstanding service to their community, their nation, and their fellow men, have been selected as recipients.

1955 ASME Semi-Annual Business Meeting Report

THE Semi-Annual Business Meeting of The American Society of Mechanical Engineers was held on June 20, 1955, in the Bay State Room of the Hotel Statler, Boston, Mass., in conjunction with the Society's 1955 Diamond Jubilee Semi-Annual Meeting.

President Morgan opened the meeting with an announcement that the 1956 Semi-Annual Meeting will be held in Cleveland, Ohio, at the Hotel Statler, June 17 through June 21.

The next item of business was the presentation of the names of the nominees for the 1956 National Nominating Committee, who were unanimously elected. Elsewhere on this page is the list of personnel of the committee.

ASME 1956 Nominating Committee Organizes

ELECTED at the 1955 Semi-Annual Business Meeting of The American Society of Mechanical Engineers, Boston, Mass., June 20, 1955, the 1956 National Nominating Committee at its organization meeting decided to defer selection of its chairman and secretary until the Chicago meeting.

Plans were made for a preliminary meeting of the Committee during the 1955 Diamond Jubilee Annual Meeting to be held in Chicago, Ill., November 13 to 18, at which arrangements will be made as to time and location of the executive meeting for nomination of the Society Officers for 1957.

The 1956 National Nominating Committee is composed of the following:

Region I. Representative, Theodore N. Graser, vice-president and treasurer, Cochrane Steam Specialty Company, 80 Federal Street, Boston 10, Mass.; *1st Alternate,* Stefan L. Grapnel, research engineer, Belding-Heminway-Corticelli Company, Putnam, Conn.; *2nd Alternate,* Roger M. Scott, sales engineer, Wire Division, Morgan Construction Company, 15 Belmont Street, Worcester, Mass.

Region II. Representative, Allen T. Kniffen, project engineer, General Engineering Division, Air Reduction Company, Inc., 60 East 42nd Street, New York 17, N. Y.; *1st Alternate,* Henry F. J. Skarbek, plant manager, American Aluminum Casting Company, 326 Coit Street, Irvington, N. J.; *2nd Alternate,* James L. O'Neill, manager, Industrial Sales Division, Daystrom Electric Corporation, 753 Main Street, Poughkeepsie, N. Y.

Region III. Representative, Joseph W. Putt, vice-president and chief engineer, Hahn Motors, Inc., Hamburg, Pa.; *1st Alternate,* Ernest H. Hanhart, consulting mechanical engineer, 9 McKim Avenue, Baltimore 12, Md.; *2nd Alternate,* Sigmund Kopp, chief engineer, Alco Products Division, American Locomotive Company, Roberts Road, Dunkirk, N. Y.

Region IV. Representative, Ray N. Benjamin, vice-president and chief engineer, Georgia Power Company, Box 1719, Atlanta 1, Ga.; *1st Alternate,* Thomas J. Judge, co-ordinator of power plants, Southern Kraft Division, International Paper Company, Box 1649, Mobile, Ala.; *2nd Alternate,* Harold K. Couch, sales engineer, Brown & Morrison, 1907 Liberty Life Building, Charlotte 2, N. C.

Region V. Representative, Henry N. Muller, Jr., assistant to vice-president, engineering, Westinghouse Electric Company, 401 Liberty Avenue, Box 2278, Gateway Center, Pittsburgh 30, Pa.; *1st Alternate,* John F. Cunningham, Jr., associate engineer and sales, Midwest Equipment Company, 545 W. Broad Street, Columbus 8, Ohio; *2nd Alternate,* Arthur B. Heiberg, development engineer, Firestone Tire & Rubber Company, 1200 Firestone Parkway, Akron 17, Ohio.

Region VI. Representative, Robert W. Mills, supervisor of conferences and institutes, 101 Architectural Hall, University of Nebraska, Lincoln, Neb.; *1st Alternate,* George H. Frost, assistant professor, General Engineering Department, Iowa State College, Ames, Iowa; *2nd Alternate,* Charles A. Davis, engineer, Deere & Company, 1325 Third Avenue, Moline, Ill.

Region VII. Representative, Harold A. Johnson, professor, mechanical engineering, University of California, Berkeley 4, Calif.; *1st Alternate,* Donald S. Angell, design engineer, Kaiser Aluminum & Chemical Corporation, Trentwood, Spokane, Wash.; *2nd Alternate,* Walter A. Biddle, sales engineer, Boyd Engineering Company, Inc., 1600 W. Jefferson Street, Phoenix, Ariz.

Region VIII. Representative, Henry B. Atherton, assistant chief operations engineer, Kansas City Power and Light Company, Postal Station "F," Kansas City 1, Mo.; *1st Alternate,* Robert W. Cox, Dallas Power & Light Company, 1506 Commerce Street, Dallas 1, Texas; *2nd Alternate,* Robert B. Kinzbach, vice-president, Kinzbach Tool Company, Inc., 2411 Summer Street, Houston 1, Texas.

Technology Group. Representative, Samuel G. Eskin, technical adviser, The Dole Vale Company, 1933 Carroll Avenue, Chicago 12, Ill.; *1st Alternate,* Otto de Lorenzi, director of education, Combustion Engineering, Inc., 200 Madison Avenue, New York 16, N. Y.; *2nd Alternate,* Harry L. Solberg, professor and head, School of Mechanical Engineering, Purdue University, Lafayette, Ind.

Codes and Standards. Representative, Frank S. G. Williams, manager, East Sales, Taylor Forge and Pipe Works, 50 Church Street, New York 7, N. Y.; *1st Alternate,* Hendley N. Blackmon, engineering manager, Association Activities, Westinghouse Electric Corporation, Office 7-L-38, East Pittsburgh, Pa.; *2nd Alternate,* A. William Meyer, assistant director of design, Brown & Sharpe Manufacturing Company, Providence 1, R. I.

Administrative. Representative, Leslie E. Herbert, 233 Union Street, Schenectady 5, N. Y.; *1st Alternate,* Raymond H. Stockard, director of placement, University of Rhode Island, Kingston, R. I.; *2nd Alternate,* Robert E. Nelson, Jr., mechanical engineer, Mech. BR., QM R&D FEA Board, Fort Lee; *for mail,* Apt. 4, 607 Summit Street, Petersburg, Va.

ASME Calendar of Coming Events

Sept. 12–14
West Coast Committee of the ASME Applied Mechanics Division, 1955 Western Conference on Applied Mechanics, U. S. Naval Post-Graduate School, Monterey, Calif.
(Final date for submitting papers was May 1, 1955)

Sept. 12–16
ASME Instruments and Regulators Division and Instrument Society of American Exhibit and Joint Conference, Los Angeles, Calif.
(Final date for submitting papers was May 1, 1955)

Sept. 25–28
ASME Petroleum-Mechanical-Engineering Conference, Roosevelt Hotel, New Orleans, La.
(Final date for submitting papers was May 1, 1955)

Oct. 10–12
ASME-ASLE Second Lubrication Conference, Antlers Hotel, Indianapolis, Ind.
(Final date for submitting papers was June 1, 1955)

Oct. 19–20
ASME-AIME Joint Fuels Conference, Neil House, Columbus, Ohio
(Final date for submitting papers was June 1, 1955)

Nov. 13–18
ASME Diamond Jubilee Annual Meeting, Hotel Congress, Chicago, Ill.
(Final date for submitting papers was July 1, 1955)

Nov. 14–18
Exposition of Power and Mechanical Engineering, as part of ASME 75th Anniversary Annual Meeting, Coliseum, Chicago, Ill.

March 14–16, 1956
ASME Aviation Division Conference, Hotel Statler, Los Angeles, Calif.
(Final date for submitting papers—Nov. 1, 1955)

March 14–15, 1956
ASME Engineering Management Conference, Hotel Statler, St. Louis, Mo.
(Final date for submitting papers—Nov. 1, 1955)

March 18–21, 1956
ASME Spring Meeting, Multnomah Hotel, Portland, Ore.
(Final date for submitting papers—Nov. 1, 1955)

March 26–27, 1956
ASME Instruments and Regulators Division Conference, Princeton University, Princeton, N. J.
(Final date for submitting papers—Nov. 1, 1955)

April 1–5, 1956
ASME Oil and Gas Power Division Conference, Jung Hotel, New Orleans, La.
(Final date for submitting papers—Dec. 1, 1955)

April 10–11, 1956
ASME Machine Design Division Conference, Bancroft Hotel, Worcester, Mass.
(Final date for submitting papers—Dec. 1, 1955)

April 16–17, 1956
ASME Gas Turbine Power Division Conference, Hotel Statler, Washington, D. C.
(Final date for submitting papers—Dec. 1, 1955)

May 8–11, 1956
ASME Metals Engineering-AWS Conference, Hotel Statler, Buffalo, N. Y.
(Final date for submitting papers—Dec. 31, 1955)

May 23–25, 1956
ASME-EIC Meeting, Mount Royal Hotel, Montreal, Que., Can.
(Final date for submitting papers—Dec. 31, 1955)

June 14–16, 1956
ASME Applied Mechanics Division Conference, University of Illinois, Urbana, Ill.
(Final date for submitting papers—Feb. 1, 1956)

June 17–21, 1956
ASME Semi-Annual Meeting, Hotel Statler, Cleveland, Ohio
(Final date for submitting papers—Feb. 1, 1956)
(For Meetings of Other Societies, see page 851)

1955 ASME Regional Delegates Discuss Society Affairs

RECOMMENDATIONS of the ASME Regional Delegates Conference, which met at the Hotel Statler, Boston, Mass., June 19–20 during the 1955 Diamond Jubilee Semi-Annual Meeting of the Society, were reported to the Council at the conclusion of the Conference and referred to the appropriate ASME committees concerned for study and suggested action. After the committees have completed their studies and have reported on them the Council will take action and prepare a report of the final disposition of each recommendation.

Through the Regional Delegates Conference, members of ASME have an opportunity to discuss Society affairs and have a voice in procedures which bring matters of importance to them to the attention of the Council in an orderly manner. Each Conference elects an Agenda Committee whose duty it is to assemble from members and sections subjects and suggestions on which action is desired. These agenda items are discussed and acted upon at meetings of the eight Regional Administrative Committees, held in the spring, each committee consisting of representatives of Sections of the region. Each region sends two delegates, a senior and a junior delegate, to the Regional Delegates Conference held at the time of the Semi-Annual Meeting. Here the agenda items, which were approved by three or more of the eight RAC Meetings, are discussed by the delegates and the final recommendations are prepared for submission to the Council.

ASME Membership as of July 31, 1955

Honorary Members	74
Fellows	406
Members	14,455
Affiliates	302
Associate Members (33 and over)	3,806
Associate Members (30–32)	4,511
Associate Members (to the age of 29)	16,176
Total	39,730

The speaker of the 1955 Conference was Allen H. Jensen, Region VIII; the vice-speaker, John P. Heumann, Region I; and the secretary was A. K. Simons, Region VI. Roll call of the delegates was made by Secretary Simons and the delegates who were present included the following (the first name given in each case is that of the senior delegate and the second, that of the junior delegate):

Region I	John P. Heumann, Fairfield County Section, and Leo M. Edwards, New Haven Section
Region II	William L. Boswell, Plainfield Section, and Gordon Hahn, Metropolitan Section
Region III	Gardner M. Ketchum, Schenectady Section, and John R. Blizard, Southern Tier Section
Region IV	John F. Mummert, Birmingham Section, and A. H. Hines, Jr., Florida Section
Region V	F. L. Schwartz, Detroit Section, and R. L. Hollaway, Jr., C-A-M Section
Region VI	A. K. Simons, Milwaukee Section, and T. R. DuBois, St. Louis Section
Region VII	William H. Swann, Inland Empire Section, and L. K. Mundth, Arizona Section
Region VIII	Allen H. Jensen, New Orleans Section, and R. G. Critz, Mid-Continent Section

All members of the 1955 Agenda Committee were present consisting of C. C. Womack, chairman; J. C. Jefferds, Jr., and J. W. Little. Speaker Jensen announced the following committees: Nominating Committee to select 1956 RDC Officers; John P. Heumann, Region I; John F. Mummert, Region IV; and William H. Swann, Region VII. The Resolutions Committee consisted of F. L. Schwartz, Region V; Gardner M. Ketchum, Region III; and William L. Boswell, Region II.

The following Officers for the 1956 Regional Delegates Conference were elected in accordance with the recommendations of the Nominating Committee: Gordon Hahn, speaker; R. L. Hollaway, Jr., vice-speaker; A. H. Hines, Jr., secretary; and Allen H. Jensen, a member of the 1956 Agenda Committee.

Resolutions of thanks and appreciation were prepared by the Resolutions Committee and signed by G. M. Ketchum, W. L. Boswell, and F. L. Schwartz, chairman.

Call for Agenda Items for 1956 RAC Meetings

THE 1956 Agenda Committee asks that each section set up an Agenda Committee to expedite the collection, editing, and submission of agenda items. This Committee is asked to canvass the membership for items and it is hoped you will support this effort one-hundred per cent. The collection of these items and the invitation to the membership to submit them through their sections is a step in the democratic process by which the membership and the sections impart their ideas to the Council.

If you live within the boundary of a section and have not been approached, we suggest you submit your items to the secretary of your section. However, if you are outside the limits of a section, we suggest you address your items to the 1956 ASME Agenda Committee, 29 West 39th Street, New York 18, N. Y. Please study the wording of your proposed items to be sure they are clear and specific, and that there can be no misunderstanding as to intent. Also, be sure the wording is positive so that action can be taken either to "approve" or "reject" the item as worded.

The following is a suggested form we ask you to use in submitting items:

ASME AGENDA ITEM

PROPOSED BY.................................of the.................. Section

Address..

Date..

Item: It is proposed that

Proposer's Comments:

....

Signature

It is earnestly requested you submit your items immediately to make it possible to mail the first compilation of the agenda by Dec. 21, 1955. The second compilation must be ready for distribution by Feb. 17, 1956, at the latest, so as to reach sections in adequate time prior to the Regional Administrative Committee meetings.

Engineering Foundation Makes 26 Research Grants

ENGINEERING research will be advanced on a wide front next year with grants made available by Engineering F[illegible]tion. At its recent annual meeting in [illegible]ork, N. Y., the Foundation approved applications totaling $61,850 for the 1955–1956 fiscal year. In a number of cases the grant is contingent upon the project's being able to raise outside support.

The grants will further 26 projects being carried out in university laboratories all over the country under sponsorship of the major engineering societies. The projects range from column research, which has been under way long enough to give definite promise of safer and cheaper structures, to a new research program for predicting disastrous storm surges in time to prevent serious loss of life.

ASCE Projects

Three grants of $1000 each have been made to projects under sponsorship of the American Society of Civil Engineers—the Column Research Council, the Research Council on

Riveted and Bolted Structural Joints, and the Reinforced Concrete Research Council—all without contingency. An ASCE-supported project on Techniques for Forecasting Waves will receive $5000 contingent upon outside support of $15,000, and another civil-engineering study on Evaluation of Alloy Steels for Fatigue Resistance in Structures will receive $2500 contingent upon raising $6500 outside support.

AIME Projects

Eight projects under sponsorship of the American Institute of Mining and Metallurgical Engineers were allotted grants. They are Alloys of Iron Research, allotted $5000 without any contingency; Heat Flow in Quenching, $2000 contingent upon raising $12,000 outside support; Diffusion in Steel, $2500 without any contingency; Comminution, $3000 contingent upon raising $10,000 outside support; Research Council on Corrosion, $4000 with a contingency of $30,000; Oscillatory Fluid Motion, $1500 without any contingency; Storm Surges, $5000 with no contingency; and Surface Diffusion on Metals, $3000 contingent upon raising $2000 outside support.

ASME Projects

Three projects under the auspices of The American Society of Mechanical Engineers were allotted grants of $1000 each without contingency. They are Fluid Meters, Effect of Temperature on Properties of Metals, and High-Temperature Steam Generation. Two other ASME-supported projects—Properties of Gases and Gas Mixtures and Properties of Steam—were granted $2500 each, also without contingency. The Fluid Meters program is one of the oldest Foundation projects that is still active, having received Foundation support off and on since 1927.

AIEE Projects

Approval was given three projects sponsored by the American Institute of Electrical Engineers. The AIEE grants are $2000 for Wood Pole Research with no contingency; $1850 for study of High-Voltage High-Frequency Dielectric Phenomena also without contingency; and $3000 for a project on Thermal-Resistivity Characteristics of Soils, contingent upon the project's receiving $12,000 outside support.

Grants for two joint projects were also approved—$5000 for Engineers' Council for Professional Development and $1000 for the Welding Research Council, both without contingency.

The Engineering Foundation has also given grants with no contingency involved to three independent projects. These grants are $3000 for a project on Prevention of Corrosion of Water Pipes; $500 for the Building Research Advisory Board; and $1000 for the Council on Wave Research.

Now in its forty-first year, The Engineering Foundation has been responsible for many noteworthy advances in the science and practice of engineering.

Meetings of Other Societies

Sept. 12–13
American Society of Lubrication Engineers, conference, Lincoln Hotel, Indianapolis, Ind.

Sept. 12–15
Society of Automotive Engineers, tractor meeting and production forum, Hotel Schroeder, Milwaukee, Wis.

Sept. 12–16
Michigan State University, seventh annual industrial-engineering conference, MSU, East Lansing, Mich.

Sept. 12–16
Instrument Society of America, tenth conference and exhibit, Shrine Exposition Hall and Auditorium, Los Angeles, Calif.

Sept. 15–16
Symposium on Corrosion, jointly sponsored by local groups of Canadian National Research Council, National Association of Corrosion Engineers, Chemical Institute of Canada, Montreal, Que., Can.

Sept. 17–Oct. 2
International Industrial and Technical Exhibition, Charleroi, Belgium

Sept. 19–22
American Institute of Mining and Metallurgical Engineers, fall meeting, Hotel Charlotte, Asheville, N. C.

Sept. 22–23
Verein Deutscher Ingenieure, conference on hardness-testing and measuring-tools exposition, Bremen, Germany

Sept. 25–28
American Society of Chemical Engineers, national meeting, Lake Placid Club, Lake Placid, N. Y.

Sept. 26–29
Association of Iron and Steel Engineers, convention, Hotel Sherman, Chicago, Ill.

Sept. 26–30
Atomic Industrial Forum, first U. S. trade fair of the atomic industry held in conjunction with annual fall meeting of the Forum and concurrent sessions of the American Nuclear Society, Sheraton-Park Hotel, Washington, D. C.

Sept. 28–29
Institute of Radio Engineers-American Institute of Electrical Engineers, industrial electronics conference, Rackham Memorial Auditorium, Detroit, Mich.

Sept. 29–Oct. 1
The Standards Engineers Society, fourth annual meeting, Hotel Statler, Hartford, Conn.

Oct. 2–5
AIME, Petroleum Branch fall meeting, Roosevelt Hotel, New Orleans, La.

Oct. 3–5
National Electronics Conference, eleventh annual, Hotel Sherman, Chicago, Ill.

Oct. 3–7
Society of Motion Picture and Television Engineers, 78th convention, Lake Placid, N. Y.

Oct. 3–7
AIEE, fall general meeting, Morrison Hotel, Chicago, Ill.

Oct. 5–9
World Plastics Fair and Trade Exposition, National Guard Armory, Los Angeles, Calif.

Oct. 8–16
"Plastics 1955" Trade Fair and Production Exhibition, Dusseldorf, Germany

Oct. 10–13
American Mining Congress, convention, Las Vegas, Nev.

Oct. 11–15
SAE, aeronautic meeting, Hotel Statler, Los Angeles, Calif.

Oct. 13–14
Engineers' Council for Professional Development, twenty-third annual meeting, King Edward Hotel, Toronto, Ont., Can.

(*ASME Calendar of Coming Events, see page 840*)

Standards Engineers to Meet in Hartford

Awards to outstanding engineers who have contributed to the development and use of standards will be one of the high lights at the fourth annual meeting of the Standards Engineers Society. The meeting will be held at Hartford, Conn., September 29–October 1. Headquarters will be the new Hotel Statler.

The awards will be presented at a luncheon Friday, September 30. Principal speaker at the morning session on that day will be C. R. DeCarlo, director of applied science, IBM World Headquarters, New York, N. Y. He will talk on the subject "Without Standards, No Automation!"

The afternoon session will be on "National Strength Related to Standardization." Moderator for the panel discussion will be Roger E. Gay, director of cataloging, standardization, and inspection, Office of the Assistant Secretary of Defense for Supply and Logistics.

A series of panel discussions on subjects of special interest to standards engineers will be the feature of the September 29 afternoon meeting.

The Saturday morning session, October 1, will be a panel discussion on "What's the Future of Standards?" Vice Admiral George F. Hussey, Jr., USN (Ret.), managing director and secretary of the American Standards Association, will be moderator of this session.

NSF Director Reports on Scientific Manpower Shortages in Industry

At least half of 200 large companies engaged in research and development—all of them in essential industries—report shortages of research scientists and engineers, according to Alan T. Waterman, Director of the National Science Foundation.

Dr. Waterman recently made public preliminary findings of a study of industrial research being made by the Bureau of Labor Statistics as part of the Foundation's national survey of scientific research and development. He described the survey to the Sixth Annual Conference on Industrial Research being held by the Department of Industrial and Management Engineering of Columbia University in Harriman, N. Y., June 6.

Dr. Waterman declared that the 200 companies interviewed in the study employ a substantial proportion of all scientists and engineers engaged in industrial research. About two thirds of the companies with shortages reported that the shortages were major. All companies agreed on the need for better-qualified, more highly trained scientists and engineers. A sizable number of firms said they had been forced to curtail projected increases in their research and development programs because of lack of qualified personnel.

The Foundation annually awards about 700 graduate fellowships in the sciences; and its programs of basic research support and research education are designed to help meet the growing needs for scientists and engineers.

Dr. Waterman also disclosed that the Foundation is sponsoring a series of fact-finding studies that will provide more complete data on the supply and demand of technical personnel than has hitherto been available. The National Register of Scientific and Technical Personnel, in co-operation with the professional societies and associations, is well advanced in the task of registering the nation's scientists and engineers.

Special studies are being made of methods for determining demand and supply of specialized personnel, of the potential supply of professional manpower in 1965, of the numbers of doctoral degrees in science issued annually.

The Foundation survey covers manpower, funds, and other essential data on the research and development being carried on by the Federal Government, by industry, and by nonprofit institutions. Reports of findings will be published as completed. One significant purpose of the survey is the acquisition of data that will help to determine what should be the role of the Federal Government in support of research.

Greater Interest in Government Fund

Three alumnus members of Tau Beta Pi's Illinois Beta chapter at Illinois Institute of Technology recently gave the Association $1000 to establish The Greater Interest in Government Fund. Frederick A. Faville, John R. LeVally, and Roy Shalstrom, of the Chicago firm Faville-LeVally Corporation, donated the money with the desire of stimulating greater interest on the part of engineering students and alumni in the American form of government.

The initial donors hope for other contributions to the fund so that an effective program can be developed to increase engineers' awareness of their responsibilities in local, state, and national government and civic affairs. A program of lectureships and other means of implementing the worthy purposes of The Greater Interest in Government Fund are under consideration.

In this age of miracles, men of science have produced many marvelous machines. The donors of The Greater Interest in Government Fund believe, however, that history will record the American form of government as the greatest machine ever devised by the mind of man. Our present-day advanced mechanical ideas have not been produced by capital nor by labor but by the co-ordination and development of the entire manufacturing process, and this, essentially, is the engineer's job. It is therefore fitting that engineering thinking should help restore Thomas Jefferson's original conception of the prerogative of higher education: "He would not educate the citizens for their own pleasure or for the mere enjoyment of living, but that they *might govern themselves*."

While a complete program is being developed for effective utilization of this new Greater Interest in Government Fund, Messrs. Faville, LeVally, and Sahlstrom have given Tau Beta Pi an additional $400 to inaugurate a series of prizes for outstanding essays written by Tau Beta Pi student initiates on the subjects of American citizenship, American government, or the responsibility of engineers to take an active part in civic and governmental affairs. These new essay prizes will be offered in conjunction with Tau Beta Pi's regular national pledge-essay contest in which student papers are judged for monetary awards twice each year. This competition is called the pledge-essay contest and has been in operation for a long period. The Greater Interest in Government prizes in each of the next four semiannual essay contests will include $65 plus a certificate for the first place winner, a second prize of $25 and a certificate, and a third place award of $10 and a certificate. Top prize essays in this new competition will also be published in Tau Beta Pi's national quarterly magazine, *The Bent*.

Frederick A. Faville will deliver an address on the subject of participation by engineers in civic and governmental affairs and will present his proposed program under The Greater Interest in Government Fund to Tau Beta Pi's 50th National Convention at Michigan State University, East Lansing, Michigan, on October 3, 1955. His address will be followed by a discussion of the subject in which the student representatives of Tau Beta Pi's 96 undergraduate chapters will take part.

SFSA Honors Memory of Gustaf A. Lillieqvist

A lifetime devoted to technical and scientific leadership in the steel-castings industry has been recognized and honored by the directors of the Steel Founders' Society through the establishment of the Gustaf A. Lillieqvist Steel Foundry Facts Award.

At the time of his death on May 31, 1955, Dr. Lillieqvist was research director of the American Steel Foundries and was intimately associated with the activities of the Steel Founders' Society of America as a member of its Technical and Research Committee. In 1952 he received the Technical and Operating Gold Medal from the society for his outstanding contributions to the technology of steel castings.

During and after World War II he served as a member of the Metallurgical Advisory Committee on Cast Armor for the Ordnance Department and was concurrently a member of the Technical Subcommittee of the Munitions Board.

Steel Foundry Facts is a monthly publication of steel-casting technology containing the papers of the technical, operating, and research men of the industry. The Gustaf A. Lillieqvist Steel Foundry Facts Award will be made annually by the board of directors for the best paper published in the preceding year. In his own lifetime, Dr. Lillieqvist was a frequent contributor to this publication.

Dr. Lillieqvist was born Sept. 20, 1894, in London, England, of Swedish parents, and after early years in Sweden he received his schooling in Switzerland where he attended the Polytechnic Institute at Zurich and obtained his degrees from the University of Berne. He came to the United States in 1924 and began his career with American Steel Foundries as a chemist at the Granite City Plant. In 1927 he was transferred to the research laboratory in Indiana Harbor where he served as assistant research director for a number of years. He was appointed research director for American Steel Foundries in 1943. He was a recipient of the Robert W. Hunt medal of the American Institute of Mining and Metallurgical Engineers and presented the 1952 American Foundrymen's Society's exchange paper before the Institute of British Foundrymen.

Dr. Lillieqvist was a member of and active in: The British Iron and Steel Institute; the American Foundrymen's Society; the Society of Automotive Engineers; the American Society for Metals; the American Welding Society; American Institute of Mining and Metallurgical Engineers; American Ordnance Association; and American Society for Testing Materials.

Starting Salaries for Engineers Continue to Increase

Starting salaries for beginning engineers continue to increase at Illinois Institute of Technology, according to figures compiled by Earl C. Kubicek, director of alumni relations and placement.

They show that the starting pay of the 1955 June engineering graduate with a bachelor of science degree climbed to $381 a month as compared to the $363 received by the 1954 June graduate.

The figure is a drop from the all-time high of $383 received by the 1955 January engineering class. But, Mr. Kubicek pointed out, the differences in the size of classes and other factors account for the invariably higher starting wage received by mid-year graduates.

Averages, based on the starting salaries of combined June and January graduating classes at IIT, have increased every year since 1949 when the average was $282 per month, Mr. Kubicek said.

In 1950 it jumped to $288; 1951, $295; 1952, $328; 1953, $362; 1954, $368, and 1955, $382.

For the first time, starting salaries of specific categories of engineers topped the $400 mark, with 1955 June electrical engineers receiving $416 and metallurgical engineers getting $404.

A year ago, electrical engineers received $386, as compared to $390 in January, 1955. Metallurgical engineers received $377 in June, 1954, and $397 in January, 1955.

Here are the beginning salary figures for all categories of IIT engineers:

	June, 1955	January, 1955	June, 1954
Electrical Engineers	$416	$390	$386
Metallurgical Engineers	$404	$397	$377
Civil Engineers	$380	$378	$375
Mechanical Engineers	$377	$392	$373
Industrial Engineers	$371	$358	$356
Chemical Engineers	$365	$398	$362
Architects	$353	no graduates	$365
Fire Protection and Safety Engineers	$348	$340	$338

(Not included in the table is the starting average of $371 for the first three technical-drawing graduates from IIT, who received their degrees in June. All three accepted teaching positions at major universities on a nine months per year basis.)

All averages are based on a 40-hour work week and apply to engineering graduates with some practical experience, Mr. Kubicek said. He explained that nearly all engineering students at Illinois Tech hold part-time or summer jobs provided by the placement office.

Averages are based on reports from 71 per cent of the IIT engineering graduating class of 225. The remaining graduates are evening students (all of whom already held full-time positions), members of the Navy and Air Force Reserve Officers' Training Corps program, others who entered immediately into military service, and those who continued on into graduate school.

Members of the June, 1955, engineering class participated in a record 1233 personal interviews with companies, arranged by the placement office, as compared to 1089 in June, 1954.

The latest mark, although an all-time high for total interviews, averaged only six interviews per graduate. The figure has run as high as nine per person in past years.

"One of the more noteworthy trends pointed up by the latest survey is the desire by organizations to secure a greater number of engineering graduates for eventual advancement to managerial and supervisory positions," Mr. Kubicek pointed out.

He said the move in that direction was underscored by the increasing demand placed on the alumni section of the IIT placement office by industry for experienced Illinois Tech engineering alumni for executive positions.

"Engineers and specialists are not the only college undergraduates getting increasingly higher salaries," Mr. Kubicek added.

He revealed that reports from half of Illinois Tech's business and economics majors showed their average starting wage to be $369 per month. A year go it was $343 and in June, 1953, was $327.

Research . . .

Aeronautical Engineering

A NEW program of research has been started in the Department of Aeronautical Engineering, Rensselaer Polytechnic Institute, Troy, N. Y., in behalf of the Air Research and Development Command, of Wright Air Development Center, Wright-Patterson Air Force Base, Ohio.

John F. Lewis and associates in the department have been authorized to open a program of research in journal-bearing instability, the first phase of the program to continue to October 31. The contract between the Air Research and Development Command and the Institute is announced by the Division of Research of the Institute.

Applied Solar Energy

THE Ford Foundation of New York, N. Y., has made a grant of $26,500 to Stanford Research Institute, Menlo Park, Calif., to assist the participation of more than 50 foreign scientists and engineers in the World Symposium on Applied Solar Energy next November.

The Symposium is slated for November 1–4 in Phoenix, with a preliminary conference at the University of Arizona, Tucson, October 31 and November 1. The Institute is planning the gatherings with the co-sponsorship of the Association for Applied Solar Energy and the University of Arizona.

"This generous assistance insures that Symposium participation will be a comprehensive representation of significant research activities in the application of solar energy in all parts of the world," Merritt L. Kastens, SRI assistant director and vice-chairman of the Symposium, said in announcing the Ford grant.

He added that, in general, priority in dispersing the funds would be given to those scientists with records of major contributions in the field of solar-energy research.

Ford Industrial Atomic-Power Study Launched

FORD Motor Company has launched a $100,000 industrial atomic-power study.

In co-operation with the Atomic Energy Commission, Ford scientists will study atomic-reactor fuel-element fabrication under the Commission's industrial participation program for the development of peacetime applications of atomic energy.

"As a major consumer of industrial power and as a mass fabricator of automotive-power plants, Ford has a vital interest in all new energy sources, including nuclear energy," E. S. MacPherson, vice-president-engineering, said.

The Ford study will be under the direction of A. A. Kucher, director of the Scientific Laboratory.

Under the program, Ford will study the specifications of fuel elements for reactor designs and the details of techniques for fabrication of these elements to determine the degree to which simplification and standardization may be effected. In addition, the company will recommend, where possible, use of mass-production processes.

The work will be done under a one-year agreement between Ford and the AEC with renewal by mutual agreement.

Fulbright Awards

THE Fulbright scholarships for graduate study abroad are open to professional persons not now engaged in college or university study. Any United States citizen between the ages of 18 and 35 with a bachelor's degree is eligible for these foreign-study awards. Applicants must be at the pre-doctoral level.

Oct. 31, 1955, is the closing date for applications for the 1956–1957 academic year. Candidates-at-large may apply directly to the Institute of International Education, 1 East 67th Street, New York City.

Opportunities are offered in the following countries in which the Fulbright program operates. Australia, Austria, Belgium and Luxembourg, Burma, Ceylon, Chile, Denmark, Egypt, Finland, France, Germany, Greece, India, Italy, Japan, The Netherlands, New Zealand, Norway, the Philippines, and the United Kingdom.

Eligibility requirements for these Fulbright awards are: (1) United States citizenship; (2) a college degree or its equivalent at the time the award is taken up; (3) knowledge of the language of the country sufficient to carry on the proposed study; (4) 35 years or under; and (5) good health.

Final selection of Fulbright grantees is made by the Board of Foreign Scholarships appointed by the President of the United States. The Institute of International Education is the agency designated by the Board of Foreign Scholarships and the Department of State to screen applications for study abroad.

These awards are made entirely in the currencies of participating countries abroad. The Fulbright Act authorizes the use of foreign currencies and credits acquired through the sale of surplus property abroad for educational exchanges. The awards cover transportation, tuition, books, and maintenance for one academic year.

G-E Program Seeks to Improve Scientific Education

MORE than 200 outstanding science and mathematics secondary-school and college teachers became pupils for six weeks this summer under the fellowship program which the General Electric Company sponsors in co-operation with four leading colleges. General Electric sponsors these programs to improve teaching in secondary schools and increase student interest and enrollment in science and mathematics courses.

Fifty secondary-school chemistry and physics teachers were chosen to study at Union College in Schenectady; 50 physics teachers to take graduate work at Case Institute of Technology, Cleveland, Ohio, and two groups of 50 mathematics teachers to study at Rensselaer Polytechnic Institute, Troy, N. Y., and Purdue University, Lafayette, Ind.

In addition to the secondary-school teachers, each university selected a small group of professors in the same fields from state teachers' colleges to participate in the program for the first time this year.

At the conclusion of this year's programs, a total of 1350 secondary-school teachers will have participated since inception of the programs 10 years ago, at a cost to G-E of about $700,000.

As part of its extensive series of programs of assistance to education, the General Electric Company supported the six weeks of study, paid traveling expenses to and from college, living expenses while attending the sessions, and tuition and fees in connection with the fellowships, thus giving the teachers expense-free advanced study.

Faculties of the colleges conduct the courses which are designed to bring teachers up to date in their fields of instruction.

In addition to underwriting the expenses associated with the programs, General Electric places some of its facilities and personnel at the

disposal of the colleges. G-E engineers, scientists, and executives are called upon to talk in their special fields. The company also arranges trips to its laboratories and plants in the area of the schools to show the teachers how important the subjects they teach will be to the future success of their students.

Oldest program is at Union which first co-operated with General Electric in a summer fellowship course in 1945. The Case program got under way in 1947. The Rensselaer program is entering its fourth year.

Industrial-Engineering Techniques Discussed at Cornell

Forty-five speakers from companies known for developing and applying new industrial-engineering techniques addressed executives, supervisors, and engineers in a series of seminars held at Cornell University in June.

The second annual Industrial Engineering Seminars, meeting from June 14–17, was sponsored by Cornell's Department of Industrial and Engineering Administration, to examine the major problems of manufacturing design, planning, and control.

Representatives came from firms employing from 15 to 300,000 persons and manufacturing products ranging from steel to aluminum foil, from plastics to aircraft.

After general-session talks on broad subjects, the participants divided into small seminars, averaging 18 to a group, for brief talks by experts and discussions of these subjects.

Seminars on industrial management, manufacturing engineering, small-plant management, work measurement, industrial statistics, and industrial marketing were headed, respectively, by Profs. Andrew Schultz, Jr., B. W. Saunders, Mem. ASME, R. E. McGarrah, M. W. Sampson, Jr., R. E. Bechhofer and R. N. Allen of Cornell, and R. W. Boettiger, Mem. ASME, sales manager of the Leslie Company in Lyndhurst, N. J.

Cost reduction was discussed in a general session by Harold F. Kneen, president of the Safety Car Heating and Lighting Company in New Haven, Conn. Suggesting a close scrutiny of selling and administrative expenses, Mr. Kneen said that his company, by closing its New York offices, saves about $80,000 a year without losing administrative effectiveness.

Operations Research

Operations research in industry was defined by M. E. Salveson, Mem. ASME, of the management-consultation-services division of General Electric. All managers of business operations, Dr. Salveson said, apply a form of operations research as they make their daily decisions. New developments in this field, he continued, result mostly by extending logical theory (mathematics, statistics, economics) to business operating problems.

C. W. Boyce, Assoc. Mem. ASME, associate editor, *Factory*, gave a general talk on automation, predicting United States productivity by statistical projections based on the past. The indicated need for two million new dwelling units a year for the next 20 years, he said, has direct implications on the need for automation. Automation means flexibility, not rigid standardization, in both product design and processing techniques, he stated.

In other general meetings, Allan Mogensen, industrial consultant from Lake Placid, N. Y., discussed the advantages of consulting workers on the easiest way to do a job; and Tell Berna, Mem. ASME, general manager of the National Machine Tool Builders Association, Cleveland, Ohio, urged a more rational economic policy for replacing obsolescent machine tools and equipment.

Human Side of Industrial Engineering

The human side of industrial engineering was discussed by John R. Bangs, Mem. ASME, director of industrial relations and personnel for the Budd Company in Philadelphia. Management's responsibility for stable employment, he declared, has been brought into focus by guaranteed annual-wage contracts the United Auto Workers Union has won.

On the fourth and final day of the seminars, the delegates discussed long-range objectives of the business firm and integrated the topics discussed during the conference.

Televised Labor-Management Arbitration Feature of AMA Personnel Conference

An actual labor-management arbitration session will be presented for the first time on closed-circuit television at the fall personnel conference of the American Management Association, September 26–28 at the Hotel Statler, New York, N. Y.

The conferees will sit in via television while a company and a union argue a disputed issue before an impartial arbitrator, who will hand down a binding decision. The session will be unrehearsed and completely in earnest. It will be televised from an upper room of the hotel onto a full-sized screen in the ballroom below.

Joseph S. Murphy, vice-president, American Arbitration Association, New York, N. Y., will serve as narrator for the half-day program. Before the telecast he will explain the background of the dispute; after the arbitration he will serve with union and company representatives on a panel that will answer questions from the audience.

National Leaders to Address Group

Opening speaker of the conference will be the Hon. Carter L. Burgess, Assistant Secretary of Defense, Washington, D. C. He will discuss the management of defense manpower, stressing the role of industry in insuring effective utilization of the nation's human resources.

Also scheduled for the first morning is a description of labor relations in United States Steel Corporation by John A. Stephens, vice-president, industrial relations, Pittsburgh, Pa. He will review his company's labor-relations policies and philosophy and its methods of long-range personnel planning.

The industrial-relations thinking of General Electric Company will be interpreted by Lemuel R. Boulware, vice-president, New York. He will emphasize G-E's use of communications in employee, community, and union relations.

The new Ford Motor Company contract will be analyzed by M. L. Denise, general industrial-relations manager, labor relations, Dearborn, Mich. Robert C. Hendon, vice-president—operations, The Railway Express Agency, Inc., New York, will interpret trends in industrial relations and their implications for management planning.

Speaker at the conference luncheon on September 28 will be John C. Whitaker, chairman of the board, R. J. Reynolds Tobacco Company, Winston-Salem, N. C. He will stress the importance of effective day-to-day communications in building good personnel relations.

Communications also will be the topic of David A. Emery, conference director, Executive Communication Course, AMA. He will take up such problems in the dynamics of communication as securing mutual understanding and co-operative action.

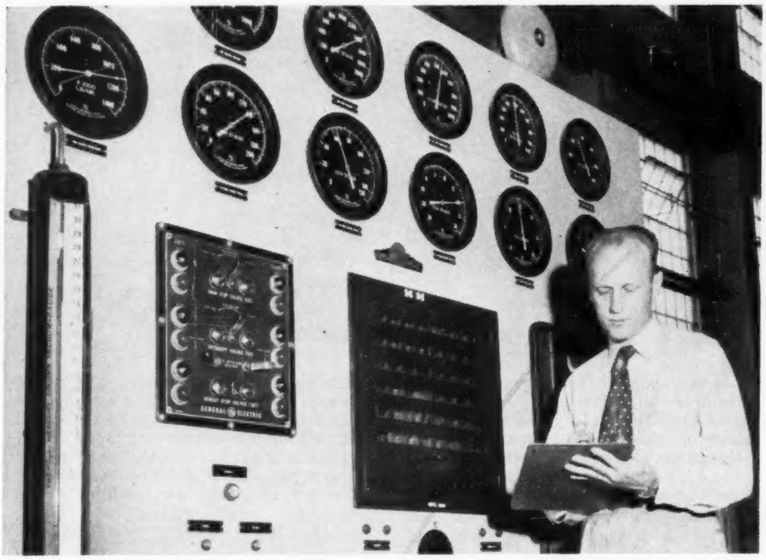
Management Development

Two panel sessions will deal with management development and the place of women in industry. Kenneth F. Herrold, guidance department, division of clinical psychology, Teachers College, Columbia University, New York, and a team of his associates will explain how management can train executives to cope with crises that arise in personnel administration. Ways to make the best use of women in business will be suggested by a panel moderated by Karon Kehoe, jobs department, *Charm* magazine, New York, with Ollie A. Randall, consultant on services for the aged, Community Service Society, New York, and Lena Ebeling, personnel director, Sherwin-Williams Paint Company, Cleveland, as members.

Other speakers at the conference will explore specific personnel techniques and labor-relations problems. Karl A. Hill, associate dean, the Amos Tuck School of Business Administration, Dartmouth College, Hanover, N. H., will evaluate industry's methods of college recruitment. The Hon. Hugh M. Milton, 2nd, Assistant Secretary of the Army, Washington, D. C., and Robert H. Willey, director of civilian personnel, Department of the Army, Washington, D. C., will describe the administration of the army's civilian personnel program. Robert C. Hood, president, Ansul Chemical Company, Marinette, Wis., will tell how Ansul uses supervisory training to make foremen cost conscious.

The story of the Pittsburgh department-store strike will be told by Samuel H. Robb, executive director, Labor Standards Association, Pittsburgh, Pa. The Rev. John M. Corridan, Xavier Labor School, New York, will discuss labor problems on the New York waterfront. Jules Backman, professor of economics, New York University, New York, will analyze the bargaining implications of the guaranteed annual wage.

Conducted by R. A. Cederberg,[1] Assoc. Mem. ASME



The author is running a performance test at Houston Lighting and Power Company

The Young Mechanical Engineer With a Public Utility

Dennis C. Tyllick[2]

In choosing a career with an electric utility the mechanical-engineering graduate enters a field which offers challenges of great variety for an imaginative and creative person. Because of the incredibly high rate of expansion of the electric utilities since the end of World War II, the conscientious young engineer will have the opportunity to gain experience and may be rewarded by advancements that other industries will find difficult to match. In addition to the monetary rewards for his work the utility engineer will derive personal satisfaction from work which helps provide a better way of life for all people at a minimum cost.

In the six years that the writer has been with his company its generating capability has more than quadrupled to over a million kilowatts and the number of generating stations has increased from three to five with a sixth now under construction. The company, although employing outside engineers for new plant design, has over one-hundred graduate engineers on its present staff, and is actively seeking to increase this force. The majority of management and supervisory personnel, including several officers of the company, are engineers who have advanced through the ranks.

First Steps in a Career

After an orientation course which all newly employed engineers are given, the young mechanical engineer will probably find himself in one of the power plants. His first position may be that of an operator and he will be rotated through the several steps in order to learn power-plant operation and the associated problems by actual experience. The practical limitations of operation and the behavior of specific equipment under various loading conditions can best be demonstrated in this manner. While acquiring this knowledge our student engineer is also learning details of generating-station equipment which will be necessary and useful to him throughout his career. After a few months of operation he will progress into the instrument and controls crew to receive training in maintenance and calibration of instruments required for automatic operation of today's power plants. Under the guidance of qualified instrument supervisors and mechanics, he studies the principles of operation and works on each individual instrument and the control system. While on this job, he will also assist the more experienced results engineers on routine testing of plant equipment.

Having acquired the practical knowledge of power-plant operation, instrumentation, and control, and other phases of the work the young engineer may now qualify for assistant results (plant-betterment) engineer. Under the surveillance of the results engineer he does general plant-engineering work and runs performance tests, checking over-all plant results as well as individual-equipment performance. He learns the necessity of thorough preparations for these tests and, what is more important, to make concise written reports of the results to his superiors.

A short period with maintenance crew and some curiosity and interest as he goes about his other work will give him "inside" information on turbines, boilers, pumps, and other equipment.

During this early training the young engineer is fortunate if he can be transferred from plant to plant to familiarize him with the plants and also to observe work methods and the handling of human problems by the several superintendents.

He accompanies senior engineers on both internal and external inspections of major equipment learning the significant details of design and construction. From this he should also learn to look for and detect signs of failure or deterioration and to be capable of evaluating the serviceability of the equipment. He will be assigned inspections of minor equipment and eventually advance to those of greater importance.

Frequently, small projects are given the young engineer for study. He must survey the project, test existing equipment if necessary, apply his technical knowledge and experience to determine a solution, and prepare plans and specifications and estimated costs for the project for submission to his superiors. Thus the young engineer handles the initial work on practically all plant engineering and has the satisfaction of following it through to completion either alone or with minor assistance of other engineers.

The mechanical engineer cannot neglect the electrical section as he must become conversant with electrical equipment and its functions in order to be capable of co-ordinating his work with that of others.

Our mechanical engineer realizes that his profession requires a knowledge of chemistry, and in the power field, while specific solution of chemical problems will be made by the plant chemist, the general methods of water analysis, boiler-feedwater treating systems, and control need be understood for successful handling of today's large steam-generating units. Analyses of fuel and other chemical tanks are routine in the power plants.

While not responsible for welding and stress relieving of high-temperature high-pressure piping, he must keep informed on metallurgical matters and on the latest methods and procedures being practiced.

The recent trend to outdoor plants has added new problems to the lengthy list of old ones

[1] Westinghouse Electric Corp., Radio-Television Division, Metuchen, N. J.

[2] Assistant Results Engineer, Houston Lighting & Power Company, Houston, Texas. Assoc. Mem. ASME.

as regards corrosion. To solve such, our mechanical engineer will seek the assistance of the chemical engineer and also of the electrical engineer if the best solution involves cathodic protection.

Our company's practice is to require our own operating-engineering staff to check both the mechanical and electrical design plans for new units, to become intimately familiar with the plant layout, and to co-ordinate design with operation. This introduces the young engineer to the problems encountered in plant design. He can later follow these plans through the construction phases to completion.

The start-up of a new station or of an extension of an existing station offers an excellent opportunity for the young engineer to become acquainted with the procedures and problems encountered in equipment of the latest design. One of our junior engineers usually works with the manufacturers' service engineers on the inspection and starting of new equipment. Attendance at manufacturers' factory schools for specialized instructions on maintenance and operation of their equipment is often included.

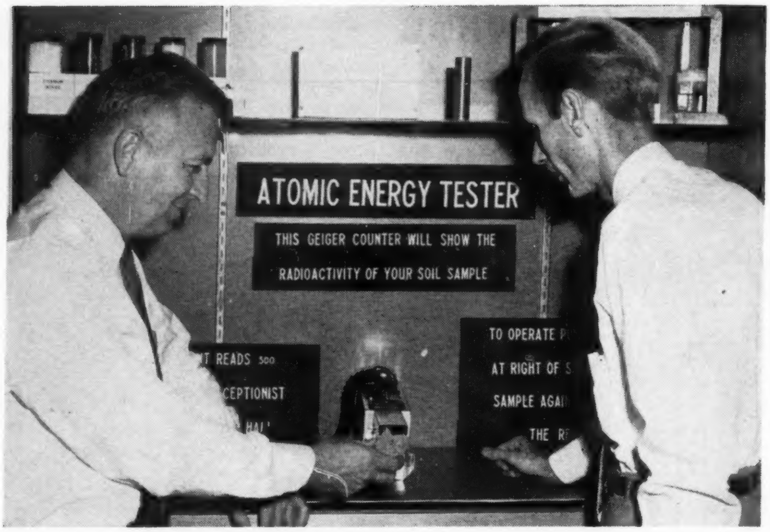
On all new units while an experienced operating engineer is usually assigned by the plant designers to assist in start-up and initial tests, our results engineers and operating staff work with him to determine performance for comparison with calculated or guaranteed conditions.

Among the problems presented by an existing plant are: Fuel-oil handling and gaging, frequent checking condenser performance and scheduling cleaning as required, analyzing unit-performance tests to determine causes for reduction in capacity, checking capacity, and performance of equipment reported to be operating at reduced capacity, preparing engineering specifications required for purchase of material, and running temperature surveys of surface-water supply used for cooling water.

A major task usually assigned mechanical engineers in power is the follow-up of system fuel economy and consumption. The basic tool for this is the loading schedules for the various stations and units for use by system-load dispatchers. Such schedules must be revised after each addition to the system and their preparation involves detailed highly theoretical thermodynamic calculations tempered with some practical considerations.

Although the electric utilities have made great strides in the past decade, the progress continues and it will be stimulated by each new advancement in metallurgy. The large highly efficient reheat units of today will be surpassed in a few short years by the supercritical pressure units now under construction. The research and design for these large units is done by the manufacturer but the development into a serviceable entity must be done at the plant. The young engineer takes an active part in the initial starting and testing of these units.

Although the power-plant engineer is kept busy combating the current problems encountered with reheat units and pressurized boilers he should not become so lost in his work that he fails to reserve a part of his time keeping informed of the latest developments and studying for the future.



University serves the community. Florida landowners and farmers can readily determine the radioactivity of their soil samples on their own, thanks to the University of Florida's College of Engineering, Gainesville, Fla. Researchers at the University have established an atomic-energy tester which the public can use in testing their samples for radioactivity. If the counter registers a sufficient amount of activity, the soil is taken to a receptionist who calls in the experts for a series of tests to determine whether or not the mining of the parent lode is economically feasible.

Thus, if he takes advantage of the many opportunities offered for experience by the industry and devotes himself to his job, the young engineer can qualify himself for advancement in today's and tomorrow's electric-utility industry. In addition to a thorough knowledge of engineering he must gain the accountant's appreciation of cost and amortization, the executive's knowledge of profitable enterprise, and the manager's capability of supervising and working with people. The young engineer who has, or can, develop these qualifications can look forward to an interesting and satisfying lifelong career with the electric utility.

. . . Chairman's Corner[3]

Chicago Meeting—Those of you within hailing distance of Chicago, Ill., had better start making your plans now to attend the Annual Meeting in November. Ted Gluck of Panellit, Inc., is planning the Junior Committee's session at this Diamond Jubilee affair. In addition to the more serious technical sessions and business meetings you'll enjoy renewing old acquaintances as you participate in the socials, dances, and tours. Drop Ted a card at Panellit, Inc., 7401 Hamlin Place, Skokie, Ill., and tell him of your plans. I might add that special arrangements are being made for inexpensive housing accommodations to cut the cost of attending the meeting. If you want to take advantage of these special accommodations get in touch with Ted by September 30 at the latest. It's easier to cancel the arrangements than to make them at the last minute.

Program-Planning Conference—This conference was held in Atlantic City, N. J., on June 29, to plan the 1956 Spring Meeting in Portland, Ore., the Joint Meeting with the EIC (Engineering Institute of Canada), and the Semi-Annual Meeting in Cleveland, Ohio, in 1956. We are planning Junior Sessions at all three of these meetings and are looking to many of you for support in programming and executing these affairs.

[3] Charles T. Miller, Chairman, National Junior Committee, Navy Department, Bureau of Aeronautics, Power Plant Division, Washington, D. C.

Literature . . .

Management Survey

More and more companies now have organized programs for developing their future leaders, according to a new survey of management development activity in American industry just published by the American Management Association, management educational association.

Fifty-four per cent of the 460 companies surveyed by the association in 1954–1955 have some systematic plan, program, or method to facilitate the development of people in or for management responsibilities. An additional 21 per cent of the responding companies, though without formal programs, have designated members of their organizations to guide or promote management development. In all, 88 per cent of the responding firms said they were giving regular attention to the problem.

Evidence that this is a new trend in business is provided by the fact that more than 80 per cent of the programs reported in the survey have been in effect for ten years or less; more than 60 per cent of them are five years old or less.

The complete report of the survey is available in book form as the AMA's Research Report No. 26, "Current Practice in the Development of Management Personnel." The 36-page paper-bound volume may be ordered through the association's publication sales division at a price to AMA members of $1.25 a copy and to others at $1.75 a copy.

Wood Handbook

An enlarged and completely revised edition of the U. S. Department of Agriculture's Wood Handbook, the bible of the woodworking and construction industries, has been issued recently by the U. S. Forest Products Laboratory, Madison, Wis.

Since the handbook was first published in 1935, it has been recognized as the outstanding reference book on the properties and structural uses of wood. It is widely referred to and quoted in specifications, building codes, engineering and structural textbooks, and other publications as a basic authority.

New research findings, together with developments in the wood-using industries, have during the past 20 years brought far-reaching changes. Since 1935, basic information about wood has been greatly broadened, new wood products have been developed, and advanced engineering principles applied to wood construction of all kinds. The new edition of the handbook includes much basic information on these materials and processes.

The use of laminated wood in large structural members was still in its infancy when the first edition of the handbook was published. Practically all of the work in sandwich construction which combines wood and other materials has been done since 1935, and the uses that have been found for plywood in the past 20 years beggar description.

The up-to-date handbook contains more than twice the number of pages of the original volume. Within its 528 pages is information on subjects that the 1935 version never even mentioned.

A new section on structural sandwich construction includes information on the fabrication and design of sandwich panels, as well as the results of extensive research on the insulation properties, fire resistance, and durability of sandwich construction.

A new section on plywood and other cross-banded products has been revised and enlarged. It features the results of much research on the strength and physical properties of plywood. The completely revised section on glued wood lamination contains the most recent information on the characteristics, design, and strength of laminated members.

Two completely new sections conclude the revamped volume. The section on building fiberboards covers various types of insulation board and structural hardboard. The section on modified woods and paper base laminates includes most of the available information on these new products of wood research.

The revised, 1955 edition of the "Wood Handbook" can be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., for $2.00 per copy, cash or money order.

Air-Conditioning Manual

A newly revised edition of "The Trane Air-Conditioning Manual" has been published by The Trane Company of La Crosse, Wis., manufacturers of air-conditioning, heating, ventilating, and heat-transfer equipment. The new 380-page edition marks the twenty-first printing and the third major revision of the air-conditioning guide.

New material has been added to the chapters on heat and comfort. Examples have been revised in the sections on heating and cooling with air, moisture calculations, latent heat calculations, dry-bulb temperature and humidity, by-passed return air, and the capacity of refrigeration plants. Also included are new data on refrigerants and refrigerating effect, quantity and condition of air supply, size of the refrigeration plant, compressors, and compressor capacity.

Copies of The Trane Air-Conditioning Manual are available through the Educational Division of The Trane Company for $6.50, postpaid, in U. S. A. Each copy is accompanied by an air-conditioning ruler, a supply of psychrometric charts, and heating and cooling load-estimate sheets.

Combustion

The volume, "Combustion Researches and Reviews, 1955," contains the invited papers presented at the sixth and seventh AGARD Combustion Panel Meetings held, respectively, in Scheveningen, The Netherlands, May, 1954, and in Paris, France, November, 1954. The papers were edited by B. P. Mullins of the National Gas Turbine Establishment, British Ministry of Supply.

The development of high-performance, high-altitude aircraft coupled with a lack of fundamental knowledge of combustion phenomena have caused combustion research to emerge as a distinct science in the past decade. Current research tends to regard combustion as a function of many sciences, and the diverse yet intimately related papers included in this book amply reflect this attitude.

It is the first of series which the AGARD Combustion Panel intends to publish under the general title Combustion Researches and Reviews, to form a permanent record of current research on important combustion problems.

The book is published for the Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization, by Butterworths Scientific Publications, 88 Kingsway, London, W. C. 2, England, and is available at $5 a copy, plus 25 cents for postage.

Engineering Economy

The first issue of a new quarterly publication devoted to engineering economy and related fields was released recently. Engineering economy is conceived to be a discipline involving decision making among alternatives in problems encompassing both engineering and economic studies.

Advancement of engineering economy has been handicapped because no adequate and appropriate medium exists where pertinent material can be presented and discussed.

Therefore the objectives of *The Engineering Economist* are to publish: Original papers; papers or summaries of papers presented at the annual meeting of the Engineering Economy Committee of the American Society for Engineering Education; reprints of papers appearing in other publications; book reviews; reports on educational problems involving engineering economy; critical comments and exchange of views; and announcements of interest.

The Engineering Economist is seeking challenging papers for publication. Price: $2 a year for the four issues; single issues 75 cents.

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., in co-operation with the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to all engineers, members or nonmembers, and is operated on a nonprofit basis.

In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrant members whose availability notices appear in these columns. Apply by letter, addressed to the key number indicated, and mail to the New York office.

When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available at a subscription of $3.50 per quarter or $12 per annum for members, $4.50 per quarter for nonmembers, payable in advance.

New York
8 West 40th St.

Chicago
84 East Randolph St.

Detroit
100 Farnsworth Ave.

San Francisco
57 Post St.

Men Available[1]

Mechanical Engineer, 23, BE; one year experience in sales engineering; desires position in application, sales engineering for mechanical equipment (power, heating, air conditioning); or industrial management position. Prefers East. ME-242.

Mechanical Engineer, Canadian, 34, BASc (ME), married; 13 years' experience, 4 supervisory and administrative, product design,

[1] All men listed hold some form of ASME membership.

machine design, plant engineering in electrical, rubber, and heavy-equipment manufacturing industries. Desires supervisory position in eastern United States. ME-243.

Mechanical Engineer, 30, married, BSME; graduate Colorado A&M. Speaks German, knows some Spanish. Nineteen months' experience in general plant engineering; 8 months' experience layout and detailing of heavy-truck parts, heavy-duty diesel engines— experience pre-college. Available August, 1955. ME-244-724-SF.

Mechanical Engineer, 30, BSME; six years' experience aviation-gas turbines, development and complete testing, including one year of drafting. Desires employment in power-plant equipment, manufacturing, or nuclear power. Prefers SE Pa. ME-246.

Production Engineer, 32, BSME; MSME; registered PE, Pa. Four years' experience as production manager for well-known manufacturer of diversified products. Desires position with broader responsibilities. ME-247.

Manager, semiretired, available to take charge of a project that needs broad business, manufacturing, and construction experience, coupled with good horse sense. Salary secondary, but profitable to both. ME-248.

Manager, Superintendent, Assistant Manager, Chief Engineer, BSEE; 48. Twenty-one years' responsible experience engineering and operation of gas, electric, steam systems; 9 years' executive position. Location desired east of Mississippi River. ME-249-277-Chicago.

Engineering Executive, PE, N. J.; creative engineer with mechanical-electrical-management background; 30, married; presently Director of Research and Development for machinery manufacturer. Desires challenging position with progressive manufacturing concern. ME-250.

Design Engineer, BS; 28; five years' engineering experience; light and heavy-machine design. Also development work on electromechanical devices. Desires Midwest. ME-251-275-Chicago.

Plant Engineer—Utilities Superintendent, registered mechanical engineer, experienced in steam-power-plant design, construction, operation. Present company being liquidated. Desires position with paper, pulp, or cement mill or mining concern. ME-253-279-Chicago.

Design Engineer, BSME; 30, six years' experience in product development; three years were in design, development, and testing of mechanical components for submarine-nuclear reactor. Desires Chicago, Ill. ME-254-280-Chicago.

Project Engineer, $4^1/_2$ years' design, development of ordnance, light equipment. Handle entire programs or separate phases. Testing specifications, inspection, contracts experience. New York City area only. Veteran. ME-255.

Project-Liaison Engineer, 30, single; BSME, MSME, MBA; six years' varied experience electromechanical and pipe-manufacturing field, including machine design, development, project co-ordination, liaison, and field surveys; two years' Navy experience air-borne radio-radar equipment; desires responsible position liaison or application engineering. Prefers northern N. J. but will relocate. ME-256.

Positions Available

Manager of Engineering, will be responsible for the operation of the product development, product design, and engineering, drafting, experimental laboratory, and test and inspection departments for manufacturer of indicators and thermometers. $10,400-$15,600, plus many other liberal benefits. New York State. W-1708.

Sales Engineer, 28–40, mechanical or electrical graduate, at least four years' experience in aircraft servo-control engineering, test-instrumentation engineering, missile-control design, or similar work, to sell aircraft instruments. $7500-$10,000 plus sales-incentive plan. New York, N. Y. W-1712.

Assistant Editor, BSME, few years' experience in petroleum or chemical company and some experience in technical capacity with petroleum refining, petrochemical manufacturing, or natural gasoline recovery. Some report writing experience. Salary open. New York, N. Y. W-1728.

Director of Engineering, 45–55, mechanical graduate, engineering and administrative experience supervising design, development, and application of aircraft, automotive and industrial equipment, and accessories. $20,000-$25,000 plus bonus. East. W-1754.

Hydraulics Engineer, research and development center, civil or mechanical graduate, under 35; should have majored in fluid mechanics, with or without experience. Salary open dependent upon qualifications. Wis. W-1765.

Engineers. (*a*) Methods engineer, 25–30, industrial-engineering graduate, experience in procedures, simplification, layout, and analysis of office methods. (*b*) Measurements engineer, young, industrial-engineering graduate, MTM experience in construction or heavy manufacturing, including preparation of costs and analysis of procedures. Salaries open. East. W-1769.

Plant Engineer, graduate civil, 30–45, preferably experience in irrigation and agricultural development, to do preventive maintenance and train equipment operators, etc. Company will provide house and will move family and furniture. $8000. Dominican Republic. F-1795.

Associate Engineer, for consulting firm, mechanical graduate, under 60, at least 20 years' experience in the design and layout of heating and ventilating systems, plumbing and water-supply systems, to take charge of the mechanical office work. Salary open. Conn. W-1809.

Chief Plant Engineer, mechanical graduate, 25–40, for power-plant operation, assist with equipment design, plant layouts, construction drawings, waste-water treatment. Salary open. Pa. W-1851.

Systems and Procedures Administrator, 25–40, BS; experienced in establishment of methods and procedures for technical operation; IBM systems, punch tape, TWX, etc.; costing a multi-product technical operation. $7000–$10,000. East. W-1864.

Director of Quality Control and Standards, 30–45, for large multiplant manufacturer of paper and board containers. To $16,000. New York, N. Y. W-1874.

Manager, Manfacturing Engineer, graduate, experienced in tool and diemaking on bench; knowledge of fabricating of tools and dies used in working brass, steel, and aluminum. Must be able to design progressive and compound dies for all types of presses; knowledge of process engineering of high-speed assemblies, methods engineering, plant layout, and automation to increase production, reduce cost, and improve quality. $12,000–$15,000. New England. W-1879.

Production or Management Engineer for manufacturer of luggage, to assist in setting up and eventually running a new department for new type of luggage. Should be experienced in plant layout, time-study methods, and incentive systems. Salary open. New England. W-1898.

Instructor or Assistant Professor, mechanical engineering, to teach some subjects in the fields of mechanics, machine design, graphics, or metal processing; MS. Opportunities for research and consulting. Starts September, 1955. New England. W-1913.

Maintenance Superintendent, to take over entire maintenance program of stone quarrying and crushing operation. Must be familiar with diesel engines, tractors, shovels, diesel trucks, crushing and screening equipment, etc. Salary open. Mideast. W-1914.

Manager in Charge of Operations, about 40–45, mechanical-engineering degree desirable, considerable operational experience in industrial rather than governmental manufacturing, preferably in a large concern fabricating precision hard goods. $15,000. New York metropolitan area. W-1917.

Plant Manager, 35–45, graduate mechanical engineer, several years' of actual production experience with a similar type of operation, closure, or can manufacturer. Will be in complete charge of manufacturing operations, including purchasing, material control, production control, planning and scheduling, and making delivery promises. Company manufactures metal bottle caps and closures. $10,000–$15,000. New York metropolitan area. W-1918.

Senior Project Engineer, graduate mechanical, 30–45, for research and development department. Will be responsible for development, design, completion, and acceptance of new products; will also be required to do market-research work in connection with new products. Some experience in aircraft field desirable. About $8500. Newark, N. J., area. W-1923.

Assistant or Associate Professor, mechanical engineering, to teach machine design, mechanisms and related subjects. $3600–$4500 for nine months with opportunity for summer work at the university or nearby manufacturers. South. W-1927.

Manufacturing Vice-President, 40–50, graduate mechanical, for a manufacturer of heavy capital goods; knowledge of forming, machining, and welding of heavy-steel plates, shapes, and castings. Wide experience in all shop processes. Knowledge of cost methods and operating finance. To $40,000. New York metropolitan area. W-1934.

Packaging Engineer, graduate mechanical, experience with small-item packaging, cartons, machinery, for high-speed mass production. $8000–$9000. Company will pay placement fee. W-1940.

Product Engineer, mechanical, qualified in the field of precision instruments. Must know manufacturing methods and how to design a product for low-cost manufacture. Should be skilled in the solution of practical, mechanical applications of the basic operating principles evolved by others. Salary open. New York, N. Y. W-1950.

Sales Engineer, graduate mechanical or electrical, five years' experience selling capital goods, preferably in the electronic field. Will be responsible for sales of measurement and control system for continuous process industries; supervise and direct sales and applications personnel, etc. Plus commission should total $10,000–$20,000. Expenses and company car. Headquarters, Midwest. W-1972.

Engineers. (*a*) Industrial engineer, graduate, experience in standards, methods, and production layout; experience in medium or large plant producing electronic equipment and machine-shop processed parts. Experience in compiling sequence of operations of mechanical manufacturing and electronic assembly. Must have two to five years' supervisory experience; some tooling experience desired. Will be responsible for establishing mass-production manufacturing methods and procedures for electronic products, etc. $5400–$6600, plus bonus. (*b*) Field-test engineer, graduate electrical or mechanical, at least two years' electronic design and/or development work essential. Should have practical experience in design and use of servomechanisms. Will study operation of and check equipment which is to be evaluated in the field; perform all necessary tests, etc. $4800–$6600, plus bonus. Midwest. W-1977

Manufacturing Manager, for a producer of heavy-industrial chemicals, 40–50, degree in chemical or mechanical engineering. Should have a minimum of 18 years in the heavy-chemical field, the last five of which should have been comparable to a works-manager level. Will be responsible for all production, maintenance, engineering functions, and for developing a proper industrial-relations climate throughout plants. Liberal salary, pension, employee benefits. Company will pay moving expenses. Midwest. W-1979.

Senior Project Engineer, mechanical or chemical-engineering graduate, at least ten years' experience covering design of process controls, electromechanical devices, and mechanisms. $8400–$9600. Ohio. W-1981 (*a*).

Associate Editor, BS in mechanical, electrical, or chemical engineering, 25–30, at least two years' experience in industry. Knowledge of photography desirable. Will be trained for work as associate editor for publication covering the plant management, maintenance, and power-plant fields. To start will work on analyzing mail and spot news. Must be draft exempt. $7500. Employer will negotiate fee. Travel 25 per cent. Southern Mich. C-3103.

Chief Engineer, Pumps, ME degree or equivalent, 35–55, at least ten years' experience in design, five years of which have been in responsible design of centrifugal pumps. Will report directly to works manager, responsible for department of four or five engineers on design of single and double suction, nonclog type of pumping equipment. Should have some field experience in addition to design experience. $7500–$10,000. Employer will negotiate fee. Chicago, Ill. C-3306.

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Chief Design and Development Engineer, mechanical graduate, at least five years as chief design and development engineer on light, fast-moving, automatic machinery. Will supervise the installation and direction of all machine-design and developing activities. Company manufactures paper products. $10,000–$20,000. Chicago, Ill. C-3387.

Works Manager, engineering degree, at least five years' experience as plant manager in plant with multiple processes and products and preferably in paper. Should have a knowledge of over-all engineering and administration of all manufacturing functions. Duties will include initiation and administration of design, installation, and supervision of all controls, procedures, systems, and methods for co-ordinating all line and staff manufacturing activities for several plants. $10,000–$20,000. Chicago, Ill. C-3391.

Chief Staff Mechanical Engineer, to 40, at least five years' experience in supervisory plant maintenance work in multiplant organization, preferably heavy chemical, steel, or mining company. Knowledge of heavy-process equipment. Will serve as staff consultant on all mechanical and plant-engineering problems and equipment for a multiplant in heavy chemical and processing field. For a manufacturer of minerals. $10,000–$12,000. Employer will negotiate fee. Considerable traveling. Chicago, Ill. C-3428.

Research Engineer, BS or MS in aeronautics or mechanical engineering, three to ten years' experience in research and development in aerodynamics, aeroballistics of aircraft projectiles and bombs. To $8400. Employer will negotiate fee. Chicago, Ill. C-3433.

Master Mechanic, five years' experience in maintenance and repair of automatic machinery and preferably canning or cup industry. Knowledge of automatic machinery. Will supervise maintenance and repair of fast-moving machinery for manufacturer of paper products. $7000–$10,000. Chicago, Ill. C-3472.

Project Engineer, mechanical graduate, at least five years' experience in the design of light-automatic machinery such as packaging equipment. Must know hydraulics and pneumatics. Will design special machinery and carry projects all the way through for a manufacturer of special machinery. $7000–$10,000. Employer will negotiate fee. Western Chicago suburb. C-3479.

Sales Engineer, mechanical or electrical graduate, 27–35, three years' experience in sales and application of electrical motors and generators. Knowledge of electric motor and generator associated control and equipment. Will sell motors and generators to established OEM and distributor accounts. Maintain present volume; assume responsibility for future expansion of sales. $6000–$7200, plus benefits. Employer will negotiate fee. Limited travel; car required. Kansas City and area. C-3487.

Superintendent, 30–50, at least three years' experience as general superintendent or general manager of an alcohol plant. Must be able to speak Spanish. Must have a knowledge of alcohol from fermentation. Will be in complete charge of production of an alcohol plant making it from molasses. $10,000–$15,000, plus expenses. South America. C-3495.

Manufacturing Vice-President, 35–45, at least five years' experience in supervising heavy-machinery operations as superintendent or works manager. Should have knowledge of management controls. Will be in full charge of manufacturing and heavy-machinery operations for two plants. $18,000–$22,000. West Coast. C-3507.

Candidates for Membership and Transfer in the ASME

The application of each of the candidates listed below is to be voted on after Sept. 26, 1955, provided no objection thereto is made before that date and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

New Applications

For Member, Associate Member, or Affiliate

Anderson, Robert C., Jackson, Mich.
Andrews, Albert M., Franklin Square, N. Y.
Atterbury, Thomas J., St. Louis, Mo.
Avalos-Vez, Leon, Mexico, D. F., Mex.
Baraya, G. Lal, Jaipur City, India
Barth, Henry W., Cleveland, Ohio
Bedford, Charles E., Marblehead, Mass.
Bondy, John K., Mexico, D. F., Mex.
Browning, Robert A., Jr., Snyder, N. Y.
Buchanan, John H., Ada, Ohio
Burman, Paul G., Longmeadow, Mass.
Burns, Donald R., Toronto, Ont., Can.
Carrig, Francis J., Bogota, N. J.
Cass, Louis D., Silver Spring, Md.
Castle, Dean R., Spokane, Wash.
Chamberlain, Albert H., Chicago, Ill.
Chao, Yu-Shai, Los Angeles, Calif.
Chenault, Woodford S., Freeport, Texas
Christlieb-Ibarrola, Alfredo, Mexico, D. F., Mex.
Christman, Paul E., Schenectady, N. Y.
Cooper, Charles G., Washington, D. C.
Cormack, Leeman J., Metaire, La.
Crowley, W. Bruce, Belmont, Calif.
Daly, John E., West Medford, Mass.
Danesi, Caesar M., Massillon, Ohio
DePoy, J. William, Oakland, Calif.
DiCerbo, Donald A., Schenectady, N. Y.
Diefenderfer, Richard P., Bradford, Pa.
Dombrowski, Leon A., Jr., Tucson, Ariz.
Easton, Donald J., Chicago, Ill.
Ellis, Charles A., Hamden, Conn.
Emslie, Norman M., Yardley, Pa.
Fairley, Richard K., Schenectady, N. Y.
Ferguson, Edgar D., Pensacola, Fla.
Flader, Fredric, North Tonawanda, N. Y.
Fort, Robert T., Evanston, Ill.
Fortmann, George W., Syracuse, N. Y.
Fuller, Robert C., Westfield, N. J.
Garay, Paul N., Towson, Md.
Gass, Robert H., Amarillo, Texas
Gillespie, Joseph W., Luling, La.
Goodpasture, Robert C., New York, N. Y.
Hasell, Samuel M., Charlotte, N. C.
Hayes, Robert C., New Orleans, La.
Hicks, Leslie A., Honolulu, T. H.
Hirsch, William L., Richmond, Va.
Hornung, David, Richmond, Va.
Howard, Darnley E., Washington, D. C.
Janovsky, Henry Z., Tel Aviv, Israel
Johnson, Robert F., New York, N. Y.
Kaufmann, Joseph N., Chicago, Ill.
Keches, Amil, McKeesport, Pa.
Kozel, William K., Cleveland, Ohio
Larson, Robert H., Batavia, Ill.
Loewenstein, Paul, Cambridge, Mass.
Maddagiri, Aswath, Philadelphia, Pa.
Mahalingam, N. Vallipuram R., Ratmalana, Ceylon
Marris, Andrew W., Vancouver, B. C., Can.
Martinez-D, Hector, Mexico, D. F., Mex.
McGraw, Michael G., Scranton, Pa.
Menne, Donald F., Bel Air, Md.
Merriam, David E., La Mesa, Calif.
O'Brien, Alfred B., Baytown, Texas
Oliver, J. William, Barberton, Ohio
Pearl, Curtis F., West Englewood, N. J.
Pence, George E., Pittsburgh, Pa.
Perkins, James S., Oak Park, Ill.
Plass, Harold J., Jr., Austin, Texas
Poer, John J., Brookfield, Ill.
Puishes, Alfons, Palo Alto, Calif.
Putnam, Laurel E., Livingston, N. J.
Ross, Kenneth R., Schenectady, N. Y.
Sachs, Edward E., Cleveland Heights, Ohio
Schupner, Willard J., Evanston, Ill.
Sparks, Cecil R., Pittsburgh, Pa.
Sprayberry, Albert A., Pensacola, Fla.
Stewart, Alexander J., Old Greenwich, Conn.
Tenkku, Wayland A., Mentor, Ohio
Thomas, Frank L., Jr., Washington, D. C.
Townsley, Malcolm G., Park Ridge, Ill.
Vaughn, William J., New York, N. Y.
Weiss, Burton, Jackson Heights, N. Y.
West, John M., Pelham, N. Y.
Whittingham, David J., New York, N. Y.
Williams, Raymond H., Buffalo, N. Y.
Wimbrow, Charles F., Lake Jackson, Texas
Winterton, Kenneth, Toronto, Ont., Can.
Witte, William J., Baltimore, Md.
Yen, Shee-Mang, Manhattan, Kan.

Change in Grading

Transfers to Member or Affiliate

Acker, David D., Whittier, Calif.
Bamb, Morris, Toledo, Ohio
Bentz, Fred A., Albuquerque, N. Mex.
Blomquist, Claes A. G., Jr., Pensacola, Fla.
Boyar, Robert E., Chicago, Ill.
Broadbent, Harry E., Jr., Philadelphia, Pa.
Byers, Norman R., Bartlesville, Okla.
Carbon, Max W., Richland, Wash.
Casselman, Daniel R., Baytown, Texas
Chen, Bu-Shing, Winter Park, Fla.
Chilton, Ernest G., Emeryville, Calif.
Clement, Joseph A., Victoriaville, P. Q., Can.
Cox, Robert W., Dallas, Texas
Cunningham, George W., Walla Walla, Wash.
Diss, Edward M., Sanford, Mich.
Donovan, William F., Clifton, N. J.
Eich, Clarence C., Signal Mountain, Tenn.
Fathauer, Jack E., Cleveland, Ohio
Fechter, Edward C., Millersville, Pa.
Flanagin, James M., Jr., Corpus Christi, Texas
Gallagher, Paul, Kingsport, Tenn.
George, Paul E., Chattanooga, Tenn.
Gluck, Theodore H., Chicago, Ill.
Goodeve, William G., London, Ont., Can.
Grimes, Arthur S., Jr., Jamaica, N. Y.
Hashizume, Toshio T., Park Forest, Ill.
Hill, Vernon R., Richland, Wash.
Katten, Stanley L., Bryn Mawr, Pa.
Krieg, Tom E., Tulsa, Okla.
Kutzelman, Elmer G., Atkinson, N. H.
Leymaster, Homer N., Beatrice, Neb.
Mayer, Charles W., Bethpage, N. Y.
Meister, Jacque L., Chicago, Ill.
Miller, Edwin W., Williamston, Mich.
Miller, Ralph W., Baltimore, Md.
Mitchell, Fred T., Jr., Kirkwood, Mo.
Morita, William L., Chicago, Ill.
Munier, Emile H., New York, N. Y.
Muth, Raymond F., Sr., York, Pa.
Naghdi, Paul M., Ann Arbor, Mich.
Schwartz, Paul P., Fort Worth, Texas
Serenbet, Warren Lewis, New York, N. Y.
Sharkey, Ellis J., Jr., New York, N. Y.
Skinner, Edward T., Dallas, Texas
Snow, Walter N., Kansas City, Mo.
Spraggins, Newton F., Wilmington, Del.
Stapleton, Fredric S., Jr., Dresden, N. Y.
Welch, Floyd E., San Mateo, Calif.
Wilson, Harold A., Troy, N. Y.

Transfers from Student Member to Associate Member 50

Obituaries . . .

Edward Emmet Alexander (1881–1955), engineer, Taylor-Wharton Iron & Steel Co., High Bridge, N. J., died June 3, 1955. Born, Paterson, N. J., Feb. 14, 1881. Parents, William and Mary (Fowler) Alexander. Education, high-school graduate; tutored in special studies. Married Mary Mace, 1905; children, Addis E., Gordon P., Robert W., Mary Elizabeth. Assoc. ASME, 1908.

Linnaeus Earl Baker (1876–1955), retired mechanical engineer, died March 9, 1955, at Long Beach, Calif. Born, North Manchester, Ind., Aug. 31, 1876. Parents, Sumner W. and Susan A. (Beeker) Baker. Education, BSME, Purdue University, 1897; ME(EE) Cornell University, 1904. Married Victoria Marie Rice, 1910. Mem. ASME, 1920. Survived by wife and two sons, Sumner R., Dhahran, Saudi Arabia, and Thomas R., Los Altos, Calif.

George Barclay Bassett (1861–1955), president, Buffalo Meter Co., Buffalo, N. Y., died April 14, 1955. Born, Ballston, N. Y., June 17, 1861. Parents, Charles R. and Elvira (Rogers) Bassett. Education, public schools; Sheffield Scientific School, Yale University, 1882-1883; and in office of Frank A. Hind, CE, Watertown, N. Y. Married Anna Kingman, 1890; children, Charles K., Robert S. Mem. ASME, 1914. He held many patents on hydraulic appliances and liquid meters. He was president, Engineers Society of Buffalo, 1918-1919; president, Engineers Society of Western N. Y., 1908.

Walter Bohnstengel (1887–1955), retired, engineer of tests, Atchison, Topeka & Santa Fe Railway, Topeka, Kan., died in October, 1954, according to a notice received by the Society. Born, Dodge City, Kan., July 22, 1887. Parents, Gottfried and Beate (Feige) Bohnstengel. Education, BS(ME), University of Kansas, 1910; ME, 1920. Upon retirement from ATSF, he concentrated on working out a method of long-range weather prediction, moisture, and temperature trends 30 to 35 years in advance. Author of several papers on Kansas fuels and oil-burning practices on Santa Fe Railway. Jun. ASME, 1915; Mem. ASME, 1924.

George T. Hammershaimb (1896–1955), con-

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sultant, Knolls Atomic Plant, General Electric Co., Schenectady, N. Y., died March 22, 1955. Born, Winterthur, Switzerland, May 26, 1896. Parents, Gunnar and Elisabeth (Helfenstein) Hammershaimb. Education, ME, Technical University of Zurich, 1919; PhD, University of Geneva, 1921. Naturalized U. S. citizen, Milwaukee, Wis., January, 1944. Married Ruth Amsler, 1937; children, Harold U., Bonnie Ruth, Robin Dora. Mem. ASME, 1940. Author of several papers on x-ray research, electrical discharge, and many on diesel-locomotive engines. He held many patents covering his research.

Phillip Alexander Kinzie (1886–1955), director of design, Mobile Pulley & Machine Co., Mobile, Ala., died April 9, 1955. His home was in San Diego, Calif. Born, Denver, Colo., July 20, 1886. Education, attended high school and served as an apprentice for five years at J. Geo. Leyner Engineering Works. Mem. ASME, 1943. Author of Section 11 of "High-Pressure Outlet Works," a handbook of applied hydraulics, by Calvin V. Davis. He was a specialist in large hydromechanical equipment.

William Gordon Kirk (1930–1955), lieutenant, USAF, was killed in the crash of his aircraft, April 21, 1955. Born, Williamsburg, Pa., Aug. 5, 1930. Parents, Mr. and Mrs. William M. Kirk of Drexel Hill, Pa. Education, graduate, Billard Academy, 1948; BS, U. S. Naval Academy, 1953. Jun. ASME, 1953.

Francis I. Markson (1907–1955), executive assistant manager of Alan A. Wood, Inc., division of B-I-F Industries, Inc., died June 18, 1955, at his home in Highland Park, Pa. Born, New York, N. Y., July 15, 1907. Parents, Harry M. and Jennie Markson. Education, high-school graduate; attended the University of Pennsylvania School of Architecture, 1924–1927. Married Beulah Clement, 1930. Assoc. ASME, 1945. Author of technical papers presented before professional societies. Survived by wife and a daughter.

Richard McCormick (1908–1955), general superintendent, steam generation, Niagara Mohawk Power Corp., Oswego, N. Y., drowned June 11, 1955, when a 22-ft cruiser exploded or burned in Lake Ontario. Born, Watertown, N. Y., June 8, 1908. Education, ChE, Rensselaer Polytechnic Institute, 1930. Mem. ASME 1954. He was the author of technical papers published in professional journals. He was married and the father of two children.

John Paul Nodine (1928–1955), lieutenant, USAF, died June 8, 1955. He had been senior draftsman, Reynolds Metal Co., Louisville, Ky. Born, Freeport, L. I., June 14, 1928. Education, Riverside Military Academy, 1944–1947; BS (ME), Alabama Polytechnic Institute, 1952. Assoc. Mem. ASME, 1954.

Duffield Prince (1876–1954), retired designing engineer, formerly with Frank Heater, Inc., Paterson, N. J., died Nov. 10, 1954. Born, Brooklyn, N. Y., April 7, 1876. Parents, Christopher and Sarah B. (Zabriskie) Prince. Education, ME, Stevens Institute of Technology, 1898. Married Ethel Ormiston Knowlton, 1908 (died May 20, 1955). Mem. ASME, 1916. Survived by daughter, Mrs. Sarah P. Coffyn, Trenton, N. J.

Kenneth Aldrich Reeve (1906–1955), supervisor, Nuclear Power Plant System, Knolls Atomic Power Laboratory, General Electric Co., Schenectady, N. Y., died May 19, 1955. Born, Sea Cliff, N. Y., June 2, 1906. Parents, Leverett A. and Louise H. Reeve. Education, EE, Cornell University, 1928. Married Grace W. Hanson, 1934. Jun. ASME, 1933; Mem. ASME, 1944. Survived by his wife.

Geoffrey Judah Siegel (1922–1955), research engineer, Operations Research Division, Battelle Memorial Institute, Columbus, Ohio, died June 21, 1955. Born, Staten Island, N. Y., Dec. 5, 1922. Parents, Morris E. and Dora G. Siegel. Education, BS(ME), Rensselaer Polytechnic Institute, 1942; graduate work at University of Akron, 1949; Ohio State University, 1951–1952. Jun. ASME, 1943. Married Elaine Persky, 1946. Survived by wife and two daughters, Erica G. and Vivian R.; his parents; a brother, Stephen; and three sisters, Mrs. M. Friedman, Mrs. G. Leventhal, Mrs. L. Rosenfeld.

Harry Walker Trump (1891–1955?), district manager, Timken Roller Bearing Co., Dallas, Texas., recently was reported to have died. Born, Canton, Ohio, Nov. 12, 1891. Parents, George and Caroline B. (Walker) Trump. Education, BME, Ohio State University, 1916. Married Jessie Amelia Menzies, 1929. Mem. ASME, 1928.

Charles Bertrand Worthen (1889–1955), engineering consultant, Madison, N. J., died May 5, 1955, at his home in Green Village, N. J. Born, Brooklyn, N. Y., July 7, 1889. Parents, Henry B. and Elizabeth (Dye) Worthen. Education, ME, Polytechnic Institute of Brooklyn, 1912. Married Adele Ethel Brodie, 1928. Mem. ASME, 1946. Survived by wife and son, Henry B. Worthen, 2nd, Warrenville, N. J.

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